Technion—Israel Institute of Technology
Department of Electrical Engineering

The Ollendorff Minerva Center for Vision and Image Sciences

A COMPREHENSIVE REPORT
1997-2004

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A Comprehensive Report of Activities

1. Introduction

The Ollendorff Minerva Center was established in 1985 in memory of the late Professor Dr. Frantz Ollendorff, the founder of the Faculty of Electrical Engineering at the Technion. Professor Ollendorff was born in Berlin in 1900. He received his Diplom-Ingenieur from the Technische Hochschule, Berlin-Charlottenburg in 1921, and the Doctor-Ingenieur in 1922. Professor Ollendorff became a leading scientist in Germany in Applied Electronics and Applied Relativity at a very young age, but was dismissed from his position and escaped to Israel. Shortly after his arrival in Israel he founded in 1938 the Faculty of Electrical Engineering at the Technion. Although his strengths and reputation were better known in applied electronics, including medical electronics, he was in particular interested in human vision and based on theoretical considerations he predicted correctly some of the functions of the human cortex.

Professor Y. Y. Zeevi, who was one of the students of Professor Ollendorff proposed to the Minerva Foundation to establish a center in the Department of Electrical Engineering in memory of Professor Ollendorff and to devote the main effort of this center to human and machine (computer) vision and to image sciences. This is in short the way the Ollendorff Center was established.

2. The Running/Administration of the Ollendorff Center and Its Membership — An Overview of the Center's Activities

In coordination with the Advisory Council, the Technion administration and the management of the Faculty of Electrical Engineering, it was decided to devote and main effort of the Ollendorff Center to topics in Vision and Image Sciences and Technologies, and from time to time to integrate and/or discontinue related research topics. A core of faculty members active in such areas was selected by a committee that included the Dean of the Faculty of Electrical Engineering, a position held by Prof. Moshe Sidi at the present time, the Director of the Center, a position held by Professor Zeevi, Prof. Moshe Eisenberg the Technion's V.P. for research, and a scientist from another Israel University. The late Professor Arnon Cohen of the Ben-Gurion University served in this position until recently. An advisory council, chaired at the present time by Prof. Dr.-Ing. Burkhardt of Freiburg, oversees the research activities of the center.

The Ollendorff Center attempts to incorporate the research activities of young promising scientists who are active in the broad range of topics relevant to Vision and Image Sciences. Two

such recent outstanding examples are Dr. Yoav Schechner and Dr. Yonina Eldar (see subsequent sections of the comprehensive report and individual reports and publications).

The Ollendorff Center does not provide funds for individual research expenses, but provides outstanding central facilities and technical support that are jointly funded by the Ollendorff Minerva Center and the Departmental budget. The laboratories for Vision and Image Sciences (VISL) have managed to keep up with the rapidly changing computer, imaging and related facilities, and to well maintain these expensive facilities by carefully budgeting these facility and technical manpower out of the Ollendorff Minerva Fund and the Departmental Technion budget. An additional form of support of individual research efforts is through the Ollendorff Graduate Fellowship Program. These Fellowships are awarded to outstanding graduate students. Several of the Ollendorff Fellows have already become faculty members at the Technion and elsewhere (e.g. G. Shapiro, a former student of Prof. Tannenbaum, who is a Professor at the University of Minnesota). Other obtained their Ph.D. and joined the research center at the industry. Ollendorff Funds are also provided for partial coverage of trips to Germany for visits to colleagues for promotion of collaborative research and/or for participation in scientific meetings taking place in Germany. Travel support is also awarded to graduate students.

Whereas the center provides facilities and technical support, faculty members of the center are expected to supplement their research budgets by grants awarded by Israeli and international foundations, as well as by the industry.

The Ollendorff Center's facilities are also available to faculty and students who are not active members of the center. However, the first priority is reserved for members. Other faculty and students have to wait for availability for access to the facilities.

Last but not least, the Ollendorff Center facilities serve also as teaching facilities in that they are available to students who select a project in vision and image sciences (or related areas) as part of the requirements of the undergraduate curriculum. Student projects in the Department of Electrical Engineering constitute an important facet of the curriculum. Students usually devote long hours in their effort to excel by producing some software, hardware, a combination of both, or an algorithm that can execute a relatively complex vision or image processing task. Some of these projects win Technion, national and international prizes. Many of these projects are actually integrated into the research program and eventually the students become co-authors of scientific papers while they are still at the stage of their undergraduate studies. An example is the research pursued by the, by-now famous, Bronstein brothers who became involved in the research programs on blind source separation and face recognition and won several national and international prizes. The Ollendorff Center attracts from time to time students from other countries. An example of a successful project accomplished by an undergraduate student from Germany is appended (Manfred Franke, student of the Technical University of Dresden).

Several students who were active in projects at the Ollendorff center were subsequently involved in the start-up company *i Sight* that developed the intelligent camera that mimics the eye,

invented at the Ollendorff Center. Several other graduates of the Ollendorff center were among the founders of several Israeli hightech companies.

The Ollendorff Center has established itself over the years as one of the important foci of research and teaching, incorporating a broad range of topics relevant to vision and image sciences. These research and teaching activities are centered primarily in the Vision and Image Sciences Laboratories (http://visl.technion.ac.il), but have been expanded in recent years into related areas in optical and electro-optical science and technologies related to computational vision and image sciences and, as such, are conducted also in a separate cluster of laboratories (see research reports of Prof. B. Fischer and Prof. M. Horowitz). Whereas topics and areas such as the electro-optical are integrated into and later on, sometime, do not continue to be an integral part of the Ollendorff Center (and this has been the case with the laboratories for Parallel Processing, i.e. the research of Dr. Birk, and of the VLSI, i.e. the research of Dr. R.Ginosar), the main theme of the Ollendorff Minerva Center has been and will continue to be Vision and Image Sciences.

The Ollendorff Center has become also an umbrella for scientific interactions among Technion's and other Israeli scientists, and colleagues from leading German universities and research institutes (see also section on cooperation). The latter is culminating every two years in a German-Israeli Binational Workshop taking place either at the Technion or in Germany. During the last seven years the Ollendorff Center either sponsored or was a partner in the organization of four such major events. In 1998 the Ollendorff Minerva Center co-sponsored with the Leibniz Institute of the Hebrew University a Workshop on Image Understanding and Computer Vision. This was jointly organized by Prof. S. Peleg of the Hebrew University, Prof. H.-H. Nagel of the Fraunhofer Gesellschaft and Y.Y. Zeevi. The Ollendorff German-Israeli Symposium on Image Processing and Computer Vision took place at the Technion in March 2000, with the participation of ten leading German scientists, including Prof. Hans Burkhart (member of the scientific committee), Prof. Joachim Buhmann (member of the scientific committee and at that time on the faculty of the University of Bonn), Prof. Christoph Schnoerr of the University of Mannheim, Prof. Gerhard Sommer, of Kiel University, who like Professors Schnoerr, Burkhart and Buhmann visited the Ollendorff Center more than once and became members of the wider family of the center. Other participants in this symposium were Prof. U. Rueckert, Prof. G. Sagerer, Prof. T. Vetter, Prof. G. Hauske, Prof. R. Klette and Prof. R. Mester. In 2002 it was proposed by our German partners and by members of the Ollendorff Beirat Committe, that the meeting should take place in Germany. The Vision and Image Science Workshop took place in October of 2002 at Schloss Dagstuhl in Wadern. Similarly to the meeting in 1998, the Israeli delegation was co-sponsored by the Libniz and Ollendorff Minerva Centers. The Israeli delegation included faculty members and graduate students from both the Hebrew University and the Technion, and representatives of both centers were members of the organizing committee, in addition to Prof. Helge Ritter and Prof. Christoph Schnoerr. The Dagstuhl Workshop dealt with fundamental issues that are essential for extraction of meaning from images: 1. Creation of lower dimensional representations of originally much higher dimensional image data – an issue of long interest and concerted effort of the Ollendorff Center, 2. Partition of images into meaningful constituents that correspond objects or actions, a topic that is dealt with also later in the subsequent Ollendorff

Workshop and is of great interest in centers in Germany and the Ollendorff Center, 3. The application of neural networks in vision processing, a topic that has been recently further expanded at the Ollendorff Center by Professor Ron Meir, and 4. The application of geometric and Algebraic mathematical concepts in vision – a topic pioneered by Prof. Gerald Sommer in Keil and by Dr. Nir Sochen of Tel-Aviv University and the Ollendorff Center. (For detail description of the course that was available to graduate students attending the Dagstuhl meeting see the section on German-Israeli Collaboration).

The last Ollendorff Workshop took place again at the Technion in October 2004, with the participation of an impressive delegation of eleven German scientists, including three graduate were students. As it turned out, most of the regular German counterparts of the Ollendorff Center were not in a position to participate in this workshop because of teaching and administrative responsibilities in their home universities. It was therefore decided to structure the workshop around a core of topics of interest to two research groups in Germany that have already established some earlier contacts with Ollendorff Center's scientists, and which there is a strong affinity to the Ollendorff Center. These are the groups of Prof. Klaus-Robert Mueller of the Fraunhofer Institute FIRST in Berlin, and the group of Prof. Joachim Weickert of Saarland University. Accordingly, an organizing committee was established, including Prof. Mueller, Prof. Weickert and Y.Y. Zeevi. In addition to scientists from these two institutes, three graduate students from these two groups participated and gave presentations, as did graduate students of the Ollendorff Center. Three sessions were devoted to the main themes of the workshop: Source separation, Variational methods, and 3D and Medical imaging. A special additional session on Image Acquisition and Enhancement was open to the industry and was attended by many scientists and engineers of the hightech industry. The Ollendorff Center can become also a pivot in promoting research of interest to industry in Germany and in Israel, similar to programs promoted by the European VI Program.

The last Ollendorff Workshop stimulated interest in collaboration among new potential research partners. Consequently, Dr. Schechner decided to make a special trip to Berlin and Kiel. In the Berlin he visited Dr. Joerge Polzhel of the Weirstrass Institute, who participated in the 2004 Ollendorff Workshop, and it is very likely that a joint research program will soon be developed. As far as the trip to Kiel, the Ollendorff Center has already long history of interaction with Prof. Gerald Sommer. This time Dr. Schechner met also with Reinhard Koch. This trip to Germany was sponsored by a special grant awarded to Dr. Schechner under the Program of "Young Scientists".

Insofar as the goal of the Ollendorff Center to promote joint German-Israeli scientific cooperation and collaboration, the Ollendorff Center has also sponsored visits of scientists and graduate students to German institutes for the purpose of giving presentations and developing joint programs. In 2004 it sponsored six such visits (see section of collaboration), including the visit of Dr. Guy Gilboa, a former graduate student of Sochen and Zeevi, to Saarland as part of the joint effort to develop closer interactions among the two groups. It is expected that Dr. Martin Welk of Weickert's group, who participated in the 2004 Ollendorff Workshop and expressed interest in the

research on blind deconvolution that is carried out at the Ollendorf Center will come for an extended visit to the Technion. Exchange of graduate students between these two groups is being explored. The visit of Dr. Y. Eldar of the Ollendorff Center to Düsseldorf University for the purpose of developing a joint research program has already resulted in a visit of one of their scientists who spends now a month at the Technion. Other interactions of Ollendorff Center's scientists with German counterparts are carried out within projects sponsored by the European Community (see the HASSIP Program on the web, and the European Network of Excellence in which Prof. R. Meir participates).

Since the last report was submitted in 2002, the research of two of the young scientists Dr. Yoav Schechner and Dr. Yonina Eldar (both of whom are recipients of the most prestigious Israeli Alon Fellowships for young scientists) has been further integrated into the center's research and teaching activities. Dr. Schechner research interests and activities are very central to those of the Ollendorff Center, in that they combine the physics of imaging media and optical components with advanced algorithms. Indeed, his interests in underwater computer vision and in clear vision in a scattering medium are complemented by the research of Dr. M. Zibulevsky and Prof. Y. Y. Zeevi in their approach to inverse problems such as Blind Source Separation and Blind Deconvolution using the novel approach of signal and image sparse representations. Several of these studies benefit from polarimetric and multispectral approaches on the one hand, and ICA or SCA (Sparse Component Analysis introduced by the Ollendorff scientists) on the other hand. The SCA was also extended to dynamic images and applied in the difficult problem of imaging through clouds (see Unger and Zeevi 2004, 2005), in addition to separation of reflections from a desired view observed through a semireflective medium (see demos on the webpage of Y. Y. Zeevi). Dr. Schechner's research on mosaicing is relevant to other research topics conducted at the center by Dr. Moshe Porat in the context of generalized sampling schemes, and by Dr. Yonina Eldar.

The work of Dr. Yonina Eldar spans a much broader range of topics and is indeed unique in its breadth and depth. Dr. Eldar is affiliated with several groups and labs in the Department of Electrical Engineering. However, her contributions to the concerted effort in several of the research activities of the Ollendorff Center are of paramount importance. Jointly with Prof. Zeevi she supervises the research of Nagesh Koundinya (who came to the Ollendorff Center all the way from India in order to specialize in the topic of Gabor Frames). This research, devoted to efficient Gabor representations, has also attracted a student from Germany who came for a short visit. A related research has resulted in a new area of multiwindow sparse Gabor representations applied to indexing, efficient storage and retrieval of macromolecules (see Koundinya and Zeevi 2005). The problem of indexing and retrieval of images is widely studied and of special interest and importance in storage of large data bases of medical images. However, with the rapid expansion of data bases of macromolecules like DNA and proteins, it becomes equally important to deal with indexing and retrieval of micromolecules. The multiwindow Gabor Frames are very suitable for highlighting and labeling of local periodicities along macromolecular sequences, such as trans membrane proteins.

The Ollendorff Center has been active for some time in the area of Medical Imaging. These activities have been enhanced by Dr. M. Zibulevsky who has been instrumental in the process of development close interactions with the Group of Prof. Klaus-Robert Mueller of the Fraunhofer Institute FIRST, Berlin. Dr. Zibulevsky has visited the center in Berlin more than once, and Prof. Mueller served on the organizing committee of the 2004 Ollendorff Workshop. The Ollendorff 2004 Workshop incorporated several topics in Medical Imaging, including three-dimensional techniques. Several of the speakers on such topics who came from Germany included Prof. Juergen Kurths of Potsdam, Prof. Hoehne and Dr. Andreas Pommert of the University Hospital, Hamburg. Earlier in May 2004, the Ollendorff Center, Jointly with the CCIT and the Galil Center sponsored a Technion Workshop on Medical Imaging that attracted more than 100 scientists and engineers from the industry. Research on medical imaging conducted by scientists of the Ollendorff Center covers also the work of Dr. M. Porat on angiography, the studies of EEG/MEG of Zibulevsky, and the studies of Zeevi on tissue signature identification by means of BSS techniques. Research in medical imaging will soon be further enhanced by Prof. Allen Tannenbaum, who is rejoining the department of Electrical Engineering and will soon become of the senior and leading scientists of this center. Prof. Tannenbaum's research is very well known in various fields, including medical imaging and image processing, as well as computer vision. His work on the application of the Laplace-Beltrimi operator in, for example, brain surface flattening has many aspects in common with the work of Sochen on the application of the Beltrami framework in low level vision. Likewise, his work on segmentation of coronary arteries in a CT scan with 3D active contours is very much related to the joint work of Sochen and Zeevi with the Ph.D. candidate Chen Sagiv, in segmentation of fully-textured images. Thus, Prof. Tannenbaum joining the Ollendorff Minerva Center, it will soon develop joint major new projects in medical imaging that will combine its various strength in representations, including sparse representations and their application in blind deconvolution and blind source separation (BSS), geometrical approaches to medical images and classification by the state-of-the-art approaches Developed by Prof. R. Meir.

The PDE approach to image enhancement, combining the conflicting requirements of denoising and edge and edge sharpening continues as a joint effort of Dr. Nir Sochen (of Tel-Aviv University) and Zeevi. Dr. Sochen, who was full time at the Technion, has moved to his home town of Tel-Aviv, and joined Tel Aviv University. However, he continues to jointly supervise graduate students with Prof. Zeevi on topics related to enhancement. Since the last report was submitted, two graduate students have completed their research and graduated from the Technion. These are Dr. Guy Gilboa, who is presently at the Institute for Applied Math at UCLA, and the other is Mr. Ran Kaftory, who completed his research towards M.Sc. and has applied for a Fellowship from the European Community in order to return for a second year of a postdoctoral position under the supervision of Tannenbaum and Zeevi. Dr. Gilboa paid a visit to Saarland, prior to his departure to the States, and developed some scientific joint project with Prof. Weickert. The interactions with the Saarland group will be further enhanced upon the return of Dr. Gilboa. Dr. Martin Welk of Saarland University, who has expressed interest in visiting the Technion for an extended period will most likely come upon the return of Dr. Gilboa. The interaction with Dr. Sochen on topics related to the PDE approach and Gabor representations

continue with the work of Chen Sagiv, a former graduate student at the Technion and presently jointly supervised by Dr. Sochen and Zeevi at Tel-Aviv University. Research on the generalized complex diffusion approach to image enhancement continues at the Ollendorff Center by Zeevi, extending the combined diffusion-Schroedinger equation to incorporate the Schroedinger potential. The latter makes it possible to deal with and enhance fully textured images.

The approach to research in the areas of Vision and Image Sciences adopted by the Ollendorff Center is unconventional in that it integrates the applied physics, applied mathematics and computer-vision-based approaches. This was one of the motivations in incorporating certain facets of the research of Prof. Fischer and Prof. Horowitz into the center. Prof. Fischer and Prof Horowitz have made unique contributions in non-linear optics, fiber optics, and the physics of short pulses. Prof. Horowitz has deep interest in optical imaging such as optical CT and imaging with optical fibers integrating signal and image processing techniques and formalisms into optical processing. For example, problems of undersampling in pulsed optical imaging systems, and representation of optical signals in combined spaces. The latter coincides with strengths of other members of the center and have the potential of new medical imaging technologies. Prof. Fischer is pushing the theory and practice of short pulses to the limits of physics and is now working on temporal image processing with light pulses. The "physics of images" and imaging is, in fact, the light-motive of Dr. Schechner's research.

The research of Prof. Ron Meir over the period of this report has been devoted to the development and analysis of advanced learning algorithms for pattern recognition and machine learning, with a recent emphasis on statistically sound and computationally efficient algorithms for feature extraction and dimensionality reduction. Part of this work is performed in the context of a European Network of excellence (Pattern Analysis, Statistical Modeling and Computational Learning) incorporating 54 European partners at 14 core sites. This work forms an important component of the research at a center focusing its effort on image analysis and vision tasks. Advanced learning algorithms require a great deal of expertise in areas statistical analysis and optimization. The latter issue has been complemented by the expertise and research activities of Dr. M. Zibulevsky. Thus, whereas scientists of the Ollendorff Center pursue their own personal research interests jointly with their students, there are also joint projects and joint supervision of graduate students. Further, the complementarity of research interests of faculty members of the Ollendorff Center enable cross-fertilization and multidisciplinary research capabilities and activities.

The interests of Prof. Meir in machine learning and pattern recognition have evolved out his original interests in biological and artificial neural networks. Recently, he became interested again in neural networks and has incorporated into the Ollendorff Center's activities new emerging paradigms of processing and learning by neural networks. This work is now tightly linked to experimental research conducted at the Technion's Medical School by Prof. Shimon Marom, who has developed means for recording simultaneously from many nerve cells within a tissue culture. Prof. Meir is currently focusing his effort on theoretical framework for the analysis of such networks, using concepts and techniques from the fields of information theory, dynamical

systems and statistical physics. This research is complemented by Prof. Zeevi in his approach to blind separation of spatio-temporal synfire sources and identification of neural cliques. Whereas the interest and approach of Prof. Meir to this field has the goal in mind of understanding biological information processing, the research of Prof. Zeevi and his students may be classified as 'biologically motivated' new approaches to processing of complex tasks such as those encountered in vision. Jointly with two brilliant graduate students he is exploring new visual architectures that can perform much more efficiently complex tasks in parallel. In the past, Zeevi and colleagues have developed an intelligent camera that mimics the eye. This was subsequently implemented in special purpose hardware that was developed by a Technion established start-up company. The work on the new architectures motivated by neural networks may well result in a new such effort of implementing new concepts in a new type of architecture. In his context it is important to mention the prolific activity of undergraduate and graduate students who work on applied project at the Ollendorff Center and eventually move rapidly into key positions in the Israeli high-tech companies, or are the founders of such companies. The Ollendorff Center has developed intimate relations and interaction with Israeli high-tech companies. As mentioned, it will attempt in the future to promote joint activities with both Israeli and German companies active in areas related to vision and image sciences.

3. Individual Research Reports and Publications

Yehoshua Y. Zeevi

Professor Zeevi is the Director of the Ollendorff Center. Most of his past and current research is devoted to topics in vision and image sciences. Professor Zeevi is a Co-editor-in-Cheif of the Journal "Visual Communication and Image Representation". He serves on various national and international committees and boards of foundations, including the Technion Board of Governors, the Swedish Academia Rodensis, and the IEEE Technical Committee on Images and multidimensional signals. He is also a member of several other editorial boards.

Prof. Zeevi is collaborating with scientists in Europe (the HASSIP Program), the United States (Columbia University, Harvard and now in the process of starting a new program devoted to MRI imaging in Cardiology, jointly with group at Stanford).

Prof. Zeevi and Dr. Zibulevsky are in the process of developing a joint research program with Prof. Mueller of the FHG in Berlin, and jointly with Sochen are exploring potential collaboration with Prof. J. Weickert and his group. Prof. Zeevi's current research interests and activities include:

- Blind Source Separation (BSS) and its application to imaging in clouding media such as blood
- Tissue signature identification in MRI and other medical imaging modalities by the application of BSS techniques.
- Image enhancement by inverse problems such as blind deconvolution (BD) and Forward-and-Backward (FAB) Diffusion techniques.
- Generalized complex diffusion techniques as operators designed for image processing.
- New architecture for image processing and computer vision, motivated by the structure and function of neural networks.
- New approaches to Indexing of Macromolecules by application of Multiwindow Gabor Representations.
- Analysis of spatio-temporal neural synfires and cliques by non-linear BSS techniques, and the application of such techniques in storage and recognition of images.
- Optimal sparse representations by nonseparable wavelets.

Graduate Students:

* D. Stanhill, Two Dimensional Wavelets for Image Representation, Ph.D. Thesis, 1997.
* D. Wietzer, Application of Generalized Wavelet, Representations in Compression and

* Filtering of Images, M.Sc. Thesis, 1998.
* P. Kissilev, Analysis of Single Evoked Potentials, M.Sc. Thesis, 1998. (Joint supervision with H. Pratt).
* R. Keren, Application of Wavelet and Gabor Transforms in Recognition of Musical Sounds, M.Sc. Thesis, 1998.
* Y. Kimchy, Identification of Evoked Potential Components based on Single Recordings, Ph.D. in BME, 2000. (Joint supervision with Prof. H. Pratt).
* T. Dar, Event Recognition Based on Analysis of Image Sequences, M.Sc Thesis, 2000. (Joint supervision with E. Rivlin).
* B. Tzipin, Dual Tracking in Visual Systems, M.Sc. Thesis, 2000. (Joint supervision with E. Rotstein).
* J. Piao, Gabor-Type Analysis of Images, M.Sc. Thesis, 2000. (Joint supervision with Dr. M. Zibulski).
* G. Caspari, Image Correspondence Algorithms based on Wavelet-Type Techniques, M.Sc. Thesis, 2001.
* A. Meir, Nonperiodic Gabor Schemes, M.Sc. Thesis, 2001. (Joint supervision with Dr. M. Zibulski).
* Chris Christoforos, Face Recognition using Normalized Symmetric Eigenfaces, M.Sc. Thesis, CUNY, NY, 2003.
* P. Kisilev, Localized Nonparametric Methods for Multidimensional Signal Processing, Ph.D. Thesis, 2003. (Joint supervision with A. Nemirovsky).
* R. Kaftory, Image Reconstruction by Energy Minimization Methods, M.Sc. Thesis, 2003. (Joint supervision with N. Sochen).
* A. Gazit, Gabor Frames, M.Sc. Thesis, 2004. (Joint supervision with M. Tzur).
* G. Gilboa, Enhancement of Images and Signals by the Application of a Generalized Diffusion-Type Process, Ph.D. Thesis, 2004. (Joint supervision with N. Sochen).
* E. Pinhasov, Progressive Resolution Algorithms for Stereo Vision, M.Sc. Thesis, 2004. (Joint supervision with N. Shimkin).

In Progress:

* C. Sagiv, Scale Space Wavelets, Ph.D. Thesis. (TAU, Joint supervision with N. Sochen).
* R. Kaftory, Harmonic Analysis Combined with Geometrical Approach to Analysis of Signals and Images, Ph.D. Thesis.
* Bronstein, Blind Deconvolution Using Sparse Representations, M.Sc. Thesis.
* (Joint supervision with M. Zibulevsky).
* H. Grosberg-Unger, Blind Source Separation of Dynamic Mixtures and Its Application in Neural Networks Cliques Analysis, M.Sc. Thesis.
* V. Kluzner, Minimal Surfaces, Measure based Distance Functions and Image Segmentation, Ph.D. Thesis. (Joint supervision with Assoc. Prof. G. Wolansky).
* N. Subbanna Koundinya, Sampling and Reconstruction in Combined Complementary Spaces for Gabor Representations, M.Sc. Thesis. (Joint supervision with Y. Eldar).
* O. Honigman, Texture Processing by Generalized Diffusion-Schrődinger Operators,M.Sc. Thesis.
* E. Orian, Blind Separation of Complex-Valued Images, M.Sc. Thesis.

Books:

1. Y. Y. Zeevi and R. Coifman (Ed's), ``Signal and Image Representation in Combined Spaces", Academic Press, 1998.
2. G. Sommer and Y.Y. Zeevi (Ed's), ``Algebraic Frames for the Perception-Action Cycle", Lecture Notes in Computer Science #1888, Springer, Berlin, 2000.

Recent Journal Papers:

1. A. B. Geva, H. Pratt and Y. Y. Zeevi, ``Multichannel Wavelet-Type Decomposition of Evoked Potential: Model-Based Recognition of Generator Activity", Medical and Biological Engineering and Computing, Vol. 35, No. 1, Jan. 1997, pp. 40-46.
2. M. Zibulski and Y. Y. Zeevi, ``Analysis of Multi-Window Gabor-Type Schemes by Frame Methods", Applied and Computational Harmonic Analysis, Vol. 4, pp. 188-221, 1997.
3. Y. Eldar, M. Lindenbaum, M. Porat and Y. Y. Zeevi, ``The Furthest Point Strategy for Progressive Image Sampling", Trans. IEEE Image Proc., Vol. 6, No. 9, Sept. 1997, pp. 1305-1315.
4. T. V. Papathomas, A. Feher, B. Julesz and Y. Y. Zeevi, ``Interactions of Monocular and Cyclopean Components and the Role of Depth in the Ebbinghaus Illusion", Perception, 1997.
5. M. Zibulski and Y. Y. Zeevi, ``Discrete Multi-Window Gabor-Type Transforms", IEEE Trans. on Signal Processing, Vol. 45, No. 6, June 1997, pp. 1428-1442.
6. Y.Y. Zeevi, M. Zibulski and M. Porat, ``Multi-Window Gabor Schemes in Signal and Image Representations", in: Gabor Analysis and Algorithms: Theory and Applications. H. G. Feichtenger and T. Strohmer (eds), Birkauser, N.Y. 1997, pp. 381—405 (Invited Paper).
7. M. Zibulski and Y.Y. Zeevi, ``The Generalized Gabor Scheme and its Application in Signal and Image Representation", in: Signal and Image Representations in Combined Spaces, Y.Y. Zeevi and R. Coifman (eds), Academic Press, Boston, 1997, pp. 121-164.
8. D. Stanhill and Y. Y. Zeevi ``Two-Dimensional Orthogonal Filter-Banks and Wavelets with Linear Phase", IEEE Trans. Signal Processing, Vol. 46, No. 1, January 1998, pp. 183-190.
9. S.G. Wolf, R. Ginosar and Y.Y. Zeevi, ``Spatio-Chromatic Image Enhancement Based on a Model of Human Visual Information Processing", J. Visual Communication Image Representation, Vol. 9, No. 1, March 1998, pp. 25-37.
10. David Stanhill and Y. Y. Zeevi, ``Frame Analysis of Wavelet-Type Filter Banks", Signal Processing, Vol. 67, No. 2, 1998, pp. 125--139.
11. E. Rivlin, H. Rotstein and Y.Y. Zeevi, ``Two-Mode Control: An Oculomotor-Based Approach to Tracking Systems". IEEE Trans. on Automatic Control, Vol. 43, No. 6, June 1998, pp. 833-842.

12. Y.Y. Zeevi, ``Multiwindow Gabor-type Representations and Signal Representation by Partial Information", in: Harmonic Analysis and its Applications, Ed. J. Byrnes, Kluwer Academic, 2001.
13. M. Zibulevsky and Y. Y. Zeevi, ``Extraction of a Source from Multichannel Data Using Sparse Decomposition", Neurocomputing, Vol. 49, 2002, pp. 163--173.
14. Y.Y. Zeevi, ``Blind Source Separation via Multimode Sparse Representation", in: Advance in Neural Information Processing Systems, Vol.~14, Morgan Kaufman, pp. 185--191, 2002.
15. G. Gilboa, N. Sochen and Y.Y. Zeevi, ``Forward-and-Backward Diffusion Process for Adaptive Image Enhancement and Denoising", IEEE Trans. on Image Processing, Vol. 11, No. 7, 2002, pp. 689-703.
16. P. Sajda, A. Laine and Y.Y. Zeevi, ``Multi-resolution and Wavelet Representations for Identifying Signatures of Disease", J. Med. Markers, Vol. 18, pp. 339-363, 200 (Invited Paper).
17. P. Kisilev, M. Zibulevsky and Y.Y. Zeevi, ``A Multiscale Framework for Blind Source Separation", J. Machine Learning Research, Vol. 4, pp. 1339-1363, 2003.
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20. G. Gilboa, N. Sochen and Y.Y. Zeevi, ``Image Enhancement and Denoising by Complex Diffusion Processes", IEEE Trans. PAMI, Vol. 26, No. 8, pp. 1020-1036, 2004.
21. M.M. Bronstein, A.M. Bronstein, M. Zibulevsky and Y.Y. Zeevi, ``Blind Deconvolution of Images Using Optimal Sparse Representations", IEEE Trans. on Image Processing 2004.
22. C. Sagiv, N. Sochen and Y.Y. Zeevi, ``Integrated Active Contours for Texture Segmentation", accepted for publication, IEEE Trans. IP, 2004 (TIP-00834-2004.R1).
23. H. Unger and Y.Y. Zeevi, "Blind Separation of Spatio-Temporal Synfire Sources and Visualization of Neural Cliques, Neurocomputing Special Issue, 2005 (Invited Paper).
24. Ehud Orian and Yehoshua Y. Zeevi, Blind Separation of Complex-valued Mixtures of Images: Sparse Representation in Polar Scatter-Plots, submitted to the EUSIPCO 2005.
25. Ehud Orian and Yehoshua Zeevi, Blind Separation of Complex-Valued Mixtures: Sparse Representation in Polar and Cartesian Scatter-Plots, submitted to the EUSIPCO 2005.

Recent Conferences:

1. “Blind Source Separation using Sparsity of Multiscale Representations”, *IEEE-EURASIP Workshop NISP'01*, Baltimore, 2001 in: Advances in Neural Information Processing Systems, Vol. 14, pp.185-191, 2002. (with P. Kisilev and M. Zibulevsky).
2. “Regularized Shock Filters and Complex Diffusion”, *ECCV 2002*, Copenhagen, May 27–June 2, LNCS 2350, pp. 299–313 Springer Verlag 2002, (with G. Gilboa and N. Sochen).
3. “Wavelet Based Multiresolution Stereo Vision”, *IEEE 3DPVT 2002*, Padova, Italy, June 19–21, 2002, (with G. Caspary).

4. "Optimal nonlinear estimation of photon coordinates in PET", *International Symposium on Biomedical Imaging, ISBI2002*, Washington DC 2002, Proc. ISBI 2002, pp. 541-544. (with A. Bronstein, M. Bronstein, M. Zibulevsky).
5. "Wavelet-based Multiresolution Stereo Vision", *ICPR 2002*, Quebec City, Canada, August 2002 (with G. Caspary).
6. "Blind Separation of Mixed Images Using Multiscale Transforms", *VCIP 2003*, Lugano, Switzerland, July 8-11, (with Pavel Kisilev and Michael Zibulevsky).
7. "Blind Separation of Mixed Images in Subspaces of Sparse Representations", *Wavelet X Conference*, San Diego, CA, August 3–8 2003, (with Pavel Kisilev and Michael Zibulevsky).
8. "Blind Separation of Mixed Images Using Multiscale Transforms", *ICIP 2003*, Barcelona, Sept. 14–17 (with Pavel Kisilev and Michael Zibulevsky).
9. "Separation of Reflections via Sparse ICA", *ICIP 2003*, Barcelona, Sept. 14–17 (with M. Bronstein, A. Bronstein and Michael Zibulevsky).
10. "PDE-Based Denoising of Complex Scenes Using a Spatially-Varying Fidelity Term", *ICIP 2003*, Barcelona, Sept. 14-17 (with G. Gilboa and N. Sochen).
11. "Color Image Denoising and Blind Deconvolusion Using the Beltramy Operator", *Proceedings of the 3rd International Symposium on Image and Signal Processing and Analysis*, Rome, Italy, September 18–20, 2003, pp. 1–4 (with R. Kaftory and N. A. Sochen).
12. "Texture Preserving Variational Denoising Using Adaptive Filtering Term", *2nd IEEE Workshop on Geometric, Variational and Level Sets Methods in Computer Vision*, Nice, France, Oct. 2003.
13. "Separation of semireflective layers using Sparse ICA", *Proc. ICASSP 2003*, Vol. 3, pp. 733–736 (with A. Bronstein, M. Bronstein and M. Zibulevsky).
14. "Quasi maximum likelihood blind deconvolution of images acquired through scattering media", *Proc. ISBI*, 2004 (with A.M. Bronstein, M.M. Bronstein and M. Zibulevsky).

Yonina C. Eldar

Recent Research Interests:

- Signal processing algorithms and applications to communication systems.
- Detection and estimation theory.
- Optimization and linear algebra methods for signal processing.
- Sampling methods and frame theory.
- Quantum signal processing.
- Communication and detection in quantum systems.
- Linear algebra and convex optimization methods for signal processing.

Graduate Students:

M.Sc. Students:

* Moshe Salhov: Equalization and multiuser detection for uncertain channels.
* Zvika Ben-Haim: Maximum-set estimation and least-squares dominating estimators.
* Noam Elron: Robust quantum detection for uncertain quantum systems.
* Nagesh Koundinya (co-supervisor: Prof. Yehoshua Zeevi): Efficient Gabor representations in combined time-frequency spaces Liron Grossman Minimax sampling and reconstruction methods.

Former Student:

* Evgeny Margolis (M.Sc. 2004): Reconstruction of periodic bandlimited signals from nonuniform samples.

Book Chapters:

1. Y. C. Eldar, "Sampling Without Input Constraints: Consistent Reconstruction In Arbitrary Spaces," *Sampling, Wavelets and Tomography*, Edited by A. Zayed and J. J. Benedetto, 2003.
2. Y. C. Eldar and A. Nehorai, "Mean-Squared Error Beamforming for Signal Estimation: A Competitive Approach", to appear in *Robust Adaptive Beamforming*, Edited by J. Li and P. Stoica.

Journal Papers:

Published (and Accepted) Articles:

1. Y. C. Eldar and A. V. Oppenheim, ``Filter Bank Reconstruction of Bandlimited Signals From Nonuniform and Generalized Samples," *IEEE Trans. Signal Processing*, vol. 48, pp. 2864-2875, Oct. 2000.

2. Y. C. Eldar and G. D. Forney, Jr., ``On Quantum Detection and the Square-Root Measurement," IEEE *Trans. Inform. Theory*, vol. 47, pp. 858-872, Mar. 2001.

3. Y. C. Eldar and A. Yeredor, ``Finite-Memory Denoising in Impulsive Noise Using Gaussian Mixture Models," IEEE *Trans. Circuits and Systems II,* vol. 48, pp. 1069-1077, Nov. 2001.

4. Y. C. Eldar, ``On Geometric Properties of the Decorrelator," *IEEE Comm. Letters*, vol. 6, pp. 16-18, Jan. 2002.

5. Y. C. Eldar and A. V. Oppenheim, ``Orthogonal Multiuser Detection," *Signal Processing*, vol. 82, no. 2, pp. 321-325, Feb. 2002.

6. Y. C. Eldar and G. D. Forney, Jr., ``Optimal Tight Frames and Quantum Measurement," *IEEE Trans. Inform. Theory*, vol. 48, no. 3, pp. 599-610, Mar. 2002.

7. Y. C. Eldar, ``Least-Squares Inner Product Shaping," *Linear Algebra Appl.*, vol. 348, pp. 153-174, May 2002.

8. Y. C. Eldar and A. V. Oppenheim, ``Quantum Signal Processing," *Signal Processing Mag.*, vol. 19, pp. 12-32, Nov. 2002.

9. Y. C. Eldar, ``Sampling and Reconstruction in Arbitrary Spaces and Oblique Dual Frame Vectors``, *J. Fourier Analys. Appl.*, vol. 1, no. 9, pp. 77-96, Jan. 2003.

10. Y. C. Eldar, ``A Semidefinite Programming Approach to Optimal Unambiguous Discrimination of Quantum States,`` *IEEE Trans. Inform. Theory*, vol. 49, pp. 446-456, Feb. 2003.

11. Y. C. Eldar and A. V. Oppenheim, ``Covariance Shaping Least-Squares Estimation," *IEEE Trans. Signal Processing*, vol. 51, pp. 686-697, Mar. 2003.

12. Y. C. Eldar, ``Constructing Signals with Prescribed Properties," *IEEE Signal Proc. Lett.*, vol. 10, pp. 82-84, Mar. 2003.

13. Y. C. Eldar, ``Mixed Quantum State Detection with Inconclusive Results," *Phys. Rev. A.*, vol. 67, pp. 042309:1-042309:14, Apr. 2003.

14. Y. C. Eldar, A. Megretski, and G. C. Verghese, ``Designing Optimal Quantum Detectors Via Semidefinite Programming," *IEEE Trans. Inform. Theory*, vol. 49, pp. 1017-1012, Apr. 2003.

15. Y. C. Eldar and H. Bolcskei, ``Geometrically Uniform Frames," *IEEE Trans. Inform. Theory*, vol. 49, pp. 993-1006, Apr. 2003.

16. Y. C. Eldar and A. V. Oppenheim, ``MMSE Whitening and Subspace Whitening," *IEEE Trans. Inform. Theory*, vol. 49, pp. 1846-1851, July 2003.

17. Y. C. Eldar and A. M. Chan, ``An Optimal Whitening Approach to Linear Multiuser Detection," *IEEE Trans. Inform. Theory*, vol. 49, pp. 2156-2171, Sep. 2003.

18. Y. C. Eldar and A. M. Chan, ``On the Asymptotic Performance of the Decorrelator", *IEEE Trans. Inform. Theory*, vol. 49, pp. 2309-2313, Sep. 2003.

19. Y. C. Eldar, ``von Neumann Measurement is Optimal for Detecting Linearly Independent Mixed Quantum States," *Phys. Rev. A*, vol. 68, pp. 052303:1-052304:4, Nov. 2003.

20. Y. C. Eldar,"Minimum Variance in Biased Estimation: Bounds and Asymptotically Optimal Estimators," *IEEE Trans. Signal Proc.*, vol. 52, pp. 1915–1930, July 2004.

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23. Y. C. Eldar, A. V. Oppenheim and D. Egnor, "Orthogonal and Projected Orthogonal Matched Filter Detection," *Signal Processing*, vol. 84, pp. 677–693, 2004.

24. Y. C. Eldar, A. Megretski and G. C. Verghese, "Optimal Detection of Symmetric Mixed Quantum States," *IEEE Trans. Inform. Theory*, vol. 50, pp. 1198–1207, June 2004.

25. O. Christensen and Y. C. Eldar, "Oblique Dual Frames and Shift-Invariant Spaces," *Applied and Computational Harmonic Analysis*, vol. 17, pp. 48–68, July 2004.

26. Y. C. Eldar, M. Stojnic and B. Hassibi, "Optimal Quantum Detectors for Unambiguous Detection of Mixed States," *Phys. Rev. A.*, 69, pp. 062318, 2004.

27. Y. C. Eldar, A. Ben-Tal and A. Nemirovski, "Robust Mean Squared Error Estimation in the Presence of Model Uncertainties," *IEEE Trans. Signal Processing*, vol. 53, pp. 168–181, Jan. 2005.

28. T. Werther and Y. C. Eldar, "General Framework for Consistent Sampling in Hilbert Spaces," to appear in *International Journal of Wavelets, Multiresolution and Information Processing*.

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30. A. Beck, A. Ben-Tal and Y. C. Eldar, "Robust Mean-Squared Error Estimation of Multiple Signals in Linear Systems affected by Model and Noise Uncertainties," to appear in *Math. Programming*.

31. A. Wiesel, Y. C. Eldar and S. Shamai (Shitz), "Linear Precoding Via Conic Programming for Fixed MIMO Receivers," to appear in *IEEE Trans. Signal Processing*.

32. Y. C. Eldar and O. Christansen, "Characterization of Oblique Dual Frame Pairs," to appear in *J. Applied Signal Processing*.

33. Y. C. Eldar, "Minimax MSE Estimation with Noise Covariance Uncertainties," to appear in *IEEE Trans. Signal Processing*.

34. Z. Ben-Haim and Y. C. Eldar, "Maximum Set Estimators with Bounded Estimation Error," to appear in *IEEE Trans. Signal Processing*.

35. T. Werther, Y. C. Eldar and N. K. Subbanna, "Dual Gabor Frames: Theory and Computational Aspects," to appear in *IEEE Trans. Signal Processing*.

36. Y. C. Eldar, "Robust Estimation in Linear Models with a Random Model Matrix," to appear in *IEEE Trans. Signal Processing*.

37. A. Wiesel, Y. C. Eldar and S. Shamai (Shitz), "Semidefinite relaxation for detection of 16-QAM signaling in MIMO channels," to appear in *IEEE Signal Proc. Lett.*.

Submitted for Publication:

38. Y. C. Eldar, "Robust Competitive Estimation with Signal and Noise Covariance Uncertainties," submitted to *IEEE Trans. Inform. Theory*, Jan. 2004.

39. R. L. Kosut, I. Walmsley, Y. C. Eldar and H. Rabitz, "Quantum State Detector Design: Optimal Worst-Case a Posteriori Performance," *http://arXiv.org/abs/quant-ph/0403150*.

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41. A. Beck, Y. C. Eldar and A. Ben-Tal, "Minimax Mean-Squared Error Estimation of Multichannel Signals," submitted to *IEEE Trans. Signal Processing*, Apr. 2004.
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47. E. Margolis and Y. C. Eldar, "Nonuniform Sampling of Periodic Bandlimited Signals: Part I–Reconstruction Theorems," submitted to *IEEE Trans. Signal Processing*, Dec. 2004.
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50. Y. C. Eldar, "Mean-Squared Error Sampling and Reconstruction in the Presence of Noise," submitted to *IEEE Trans. on Signal Processing,* Dec. 2004.
51. Y. C. Eldar and A. Nehorai, "A Competitive Mean-Squared Error Approach to Beam-forming," submitted to *IEEE Trans. on Signal Processing,* Jan. 2005.
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2. Y. C. Eldar, "Minimum Mean-Squared Error Covariance Shaping," *Int. Conf. Acoust., Speech, Signal Processing*, 2003.
3. Y. C. Eldar and H. Bolcskei, Structured Group Frames," *Proceedings of the 2003 Workshop on Sampling Theory and Applications (SampTA'03)*, May 2003.
4. E. Margolis and Y. C. Eldar, "Filterbank Reconstruction of Periodic Signals and Sampling in Polar Coordinates," *Proceedings of the 2003 Workshop on Sampling Theory and Applications (SampTA'03)*, May 2003.
5. T. Werther and Y. C. Eldar, "Geometrical Interpretation of Consistent Sampling," *Proceedings of the 2003 Workshop on Sampling Theory and Applications (SampTA'03)*, May 2003.
6. Y. C. Eldar, "Optimal Quantum State Discrimination and the Equal Probability Measurement," *IEEE Symp. Inform. Theory 2003*.
7. Y. C. Eldar and S. Shamai (Shitz), "Covariance Shaping Multiuser Detection," *IEEE Symp. Inform. Theory, 2003*.

8. Y. C. Eldar and N. Merhav, "Robust Linear Estimation with Covariance Uncertainties," *Proc. Stat. Signal Processing Workshop*, Sep. 2003.
9. A.Weisel, Y. C. Eldar, and S. Shamai (Shitz), "Multiuser Precoders for Fixed Receivers," *International Zurich Seminar on Communications*, 2004.
10. Y. C. Eldar, A. Ben-Tal and A. Nemirovski, "Minimax Regret Estimation in Linear Models," *Int. Conf. Acoust., Speech, Signal Processing (ICASSP-2004)*.
11. E. Margolis and Y. C. Eldar, "Interpolation With Nonuniform B-Splines," *Int. Conf. Acoust., Speech, Signal Processing (ICASSP-2004)*.
12. Wiesel, Y. C. Eldar and S. Shamai (Shitz), "Linear MIMO Precoders for Fixed Receivers," *Int. Conf. Acoust., Speech, Signal Processing (ICASSP-2004)*.
13. M. Selhov, A. Wiesel and Y. C. Eldar, "Robust Peak Distortion Equalization," *Int. Conf. Acoust., Speech, Signal Processing (ICASSP-2004)*.
14. Y. C. Eldar and A. Nehorai, "Competitive Mean-Squared Error Beamforming" *Proc. 12th Annu. Workshop Adaptive Sensor Array Processing*, Lincoln Laboratory, MIT, Lexington, MA, Mar. 2004.
15. Y. C. Eldar and A. Nehorai, "Uniformly Robust Mean-Squared Error Beamforming," *SAM2004*, July 2004.
16. Y. C. Eldar, "MSE-Ratio Regret Estimation with Bounded Data Uncertainties," *EUSIPCO*, Sep. 2004.
17. Y. C. Eldar, "Vector Uniform Cramer-Rao Lower Bound," *EUSIPCO*, Sep. 2004.
18. M. Salhov, A. Weisel and Y. C. Eldar, "A Robust Maximum Likelihood Multiuser Detector in the Presence of Signature Uncertainties," *EUSIPCO*, Sep. 2004.
19. Y. C. Eldar and T. Rudolph, "Optimal Maximum-Control Strategies," *The Seventh International Conference on Quantum Communication, Measurement and Computing*, July 2004.
20. Z. Ben-Haim and Y. C. Eldar, "Estimation with Maximum Error Requirements", *23rd IEEE Convention of Electrical and Electronics Engineers in Israel (IEEEI-2004)*.
21. E. Margolis and Y. C. Eldar, "Nonuniform Sampling in Polar Coordinates with Applications to Computerized Tomography," *23rd IEEE Convention of Electrical and Electronics Engineers in Israel (IEEEI-2004)*.
22. N. K. Subbanna and Y. C. Eldar, "A Fast Algorithm for Calculating the Dual Gabor Window with Integer Oversampling," *23rd IEEE convention of Electrical and Electronic Engineers in Israel (IEEEI-2004)*.
23. E. Margolis and Y. C. Eldar, "Reconstruction of Nonuniformly Sampled Periodic Signals: Algorithms and Stability Analysis," *11th IEEE Int. Conf. Electronics, Circuits and Systems (ICECS-2004)*.
24. Y. C. Eldar and T. G. Dvorkind, "Minimax Sampling With Arbitrary Spaces", *11th IEEE Int. Conf. Electronics, Circuits and Systems (ICECS-2004)*.
25. N. K. Subbanna and Y. C. Eldar, "Efficient Gabor Expansion Using Nonminimal Dual Gabor Windows", *11th IEEE Int. Conf. Electronics, Circuits and Systems (ICECS-2004)*.

Baruch Fischer

Recent topic: Temporal Image Processing with Light Pulses

***Short summary*:**
Our research was done in two directions:

I. ***Temporal Image Processing of Optical Pulses:***

We advanced the optical pulse processing work in fibers. Temporal pulse operations stem from the analogy of space and diffraction vs. time and dispersion behavior of light propagation. It provides many new ideas and potential "electro-optical" and "all-optical" image processing ideas in the time domain of short light pulses. Pulse propagation, its formation, propagation and processing are the focus of this research.
We have conducted a theoretical and experimental research in the way pulses are processed in fibers by electro-optic and nonlinear–optics methods.

Examples for the work are (the others are given in the papers listed below.):

1. Compression of periodic light pulses using all-optical repetition rate few titles
2. Repetition rate multiplication of optical pulses using uniform fiber Bragg gratings
3. Characterization of Optical Pulses by Real-Time Spectral Interferometry
4. Frequency shifting of microwave signals using a general temporal self-imaging effect
5. Spectro-temporal imaging of optical pulses with a single time lens
6. Simplified Temporal Imaging Systems for Optical Waveforms

Detailed summaries for all topics of this section can be found in papers 1-15 in the list below.

II. ***The Physics of Pulse Formation; a Statistical Light-mode Dynamics (SLD) approach:***

We have developed a completely new approach in laser physics that combines a new basic statistical mechanics approach to light and laser physics. This became a Statistical Light-mode Dynamics (SLD) approach that provides a new and very different way to learn complex nonlinear light systems and lasers.
The work is described in Papers no. 17-24 of the list below.

Examples for the work are (the others are given in the papers listed below.):

1. Statistical mechanics theory of active mode locking with noise
2. Formation and annihilation of laser light pulse quanta in a thermodynamic-like pathway
3. Critical behavior of Light

Detailed summaries all topics of this section can be found in papers 16-24 in the list below.

The Research Group:
Principal Investigator: Prof. Baruch Fischer
Researchers:

1. Dr. Naum Berger
2. Dr. Alexander Bekker
3. Dr. Boris Levitt
4. Vladimir Shmulakovski

Graduate Students:

5. Ofer Shapira
6. Assaf Ben-Bassat
7. Shimie Atkins
8. Ariel Gordon
9. Boris Vodonos
10. Rafi Weill
11. Michael Katz
12. Amir Rosen
13. Chen Zach

Recent Publications:

1. B. Fischer, A. Rosen, A. Bekker and S. Fishman, "Experimental Observation of Localization in the Spatial Frequency Domain of Optical Kicked System", *Phys. Rev. E* 61:R4694, 2000.
2. Rosen, B. Fischer, and S. Fishman, "Optical Kicked System Exhibiting Localization in the Spatial Frequency Domain", *J. Optical Society of Am.* B17: 1579, 2000.
3. Fischer, B. Vodonos, S. Atkins and B. Fischer, "Dispersion-mode pulsed laser", *Opt. Lett*. 25:728, 2000.
4. N. Berger, B. Levit, A. Bekker and B. Fischer, "Real-time optical spectrum analyzer based on chirped fiber Bragg gratings", *Elect. Lett*. 36:1189, 2000.
5. N. Berger, B. Levit, S. Atkins and B. Fischer, "Time-lens based spectral analysis of optical pulses by electrooptic phase modulation", *Electr. Lett*. 36:1644, 2000.
6. N. Berger, B. Levit and B. Fischer, "Optical pulse intensity and phase measurement by time-to-space conversion based on time-lens operation", *Electr. Lett*. 37:1033, 2001.
7. B. Fischer, B. Vodonos, S. Atkins and A, Bekker, "Demonstration of Localization in the Frequency Domain of Mode-locked Lasers with Dispersion", *Opt. Lett*. 27:1061, 2002.
8. Gordon and B. Fischer, "Phase transition theory of many-mode ordering and pulse formation in lasers", *Phys. Rev. Lett*. 89:103901, 2002.

9. S. Atkins and B. Fischer, “All-optical pulse rate multiplication by fractional Talbot effect and field to intensity conversion with cross gain modulation”, *Photonics Technology Letters*. 15:132, 2003.
10. N. K. Berger, B. Vodonos, S. Atkins, V. Smulakovsky, A. Bekker, and B. Fischer, “Compression of periodic light pulses using all-optical repetition rate multiplication”, *Opt. Comm*., Vol. 217, p. 343, 2003.
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12. N. K. Berger, B. Levit, S. Atkins, and B. Fischer, “Repetition rate multiplication of optical pulses using uniform fiber Bragg gratings”; *Opt. Comm*., Vol. 221, p. 331, 2003.
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14. S. Atkins, A. Rosen, A. Bekker, and B. Fischer, “Evolution of localization in frequency for modulated light pulses in a recirculating fiber loop”, *Opt. Lett*. Vol. 28, p. 2228, 2003.
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16. J. Azana, N. K. Berger, B. Levit and B. Fischer, “Spectro-temporal imaging of optical pulses with a single time lens"; *IEEE Photon. Technol. Lett*. Vol. 16, p. 882, 2004.
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18. A. Ben-Bassat, A. Gordon and B. Fischer, “High order stimulated Brillouin scattering in single-mode fibers with strong feedback*”, Ukr. J. Phys.* Vol. 49 (5), p. 496, 2004. (http://www.ujp.bitp.kiev.ua/v49/papers/490513p.pdf)
19. O. Shapira and B. Fischer, “Light Localization in Randomly Spaced Grating Array in a Single Mode Fiber”. Submitted for publication.
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21. J. Azana, N. K. Berger, B. Levit, V. Smulakovsky and B. Fischer, "Frequency shifting of microwave signals using a general temporal self-imaging (Talbot) effect in optical fibers"; *Opt. Lett*. Vol. 29, p. 2849, 2004.
22. J. Azana, N. K. Berger, B. Levit and B. Fischer, "Simplified Temporal Imaging Systems for Optical Waveforms"; *IEEE Photon. Technol. Lett*. Vol. 17, 94, 2005.
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25. A. Gordon, B. Vodonos, V. Smulakovski, and B. Fischer, "Melting and freezing of light pulses and modes in mode-locked lasers," Opt. Express Vol. **11,** p. 3418, 2003, (http://www.opticsexpress.org/abstract.cfm?URI=OPEX-11-253418)
26. A. Gordon and B. Fischer, "Phase transition theory of pulse formation in passively mode-locked lasers with dispersion and Kerr nonlinearity"; " *Opt. Comm*., Vol. 223, p. 151, 2003.
27. A. Gordon and B. Fischer, "Inhibition of modulation instability in lasers by noise"; *Opt. Lett*. Vol. 28, p. 1326, 2003.
28. A. Gordon and B. Fischer, "Statistical mechanics theory of active mode locking with noise"; *Opt. Lett*. Vol. 29, p. 1022, 2004.
29. O. Gat, A. Gordon and B. Fischer, "Solution of a statistical-mechanics model for pulse formation in passively lasers", Phys Rev E, Vol. 70, 046108, 2004; also appears in http://arxiv.org/cond-mat/0311241 Nov. 11, 2003.
30. B. Vodonos, R. Weill, A. Gordon, V. Smulakovsky, A. Bekker. O. Gat and B. Fischer, "Formation and annihilation of laser light pulse quanta in a thermodynamic-like pathway"; *Phys. Rev. Lett*. Vol. 93, 153901, 2004. (also appears in http://arXiv.org/cond-mat/0411525)
31. O. Gat, A. Gordon and B. Fischer, "Exact solution of the nonlinear laser passive mode locking transition"; Submitted for publication. also appears in http://arXiv.org/abs/cond-mat/0407514 , July 20, 2004.
32. R. Weill, A. Rosen, A. Gordon, O. Gat and B. Fischer, "Critical behavior of Light". Submitted for publication.
33. Ariel Gordon, Omri Gat , Franz X. Kärtner, and Baruch Fischer, "Self-starting of passive mode locking". Submitted for publication.

Recent Conferences:

1. N. K. Berger, B. Levit, S. Atkins, and B. Fischer, "Repetition rate multiplication of optical pulses using fiber Bragg gratings", *Optical Fiber Comm. Conf. OFC-02*, Anaheim, March 2002.
2. N. K. Berger, B. Vodonos, S. Atkins, V. Smulakovsky, A. Bekker, and B. Fischer, "Compression of periodic optical pulses without propagation in dispersive delay line", *Conf. on Lasers and Electro-Optics (CLEO'02)*, Long Beach CA, May 2002.
3. S. Atkins, A. Rosen, A. Bekker, and B. Fischer, "Evolution of localization in frequency for modulated light pulses in a recirculating fiber loop", *Conf. on Lasers and Electro-Optics (CLEO'02)*, Long Beach CA, May 2002.
4. Gordon and B. Fischer, "Phase transition theory for passive mode-locking of lasers", *Conf. on Lasers and Electro-Optics (CLEO'02*), Long Beach CA, May 2002.
5. S. Atkins, D. Dahan and B. Fischer, "All-optical pulse rate multiplication using fractional Talbot effect and field to intensity conversion with cross gain modulation", *ECOC-02*, Copenhagen, September 2002.
6. Gordon and B. Fischer, "Formation and destruction of pulses in lasers - a noise induced phase transition", American Physical Society *(APS) March Meeting*, Austin, Texas, 2003.

7. Gordon, B. Vodonos, V. Smulakovsky, A. Bekker, and B. Fischer, "Experimental demonstration of first order phase transition in pulse formation in passive mode locked lasers", *Conf. on Lasers and Electro-Optics (CLEO)*, Baltimore 2003.
8. Vodonos, A. Gordon, V. Smulakovsky, A. Bekker, and B. Fischer, "Threshold power dependence on noise in passive mode locking", *Conf. on Lasers and Electro-Optics (CLEO)*, Baltimore 2003.
9. Fischer, A. Gordon and B. Vodonos, Invited paper on "Some physical scenes (melting, freezing and localization) from a birthplace of light pulses (mode-locked lasers)", *European Quantum Electronics Conference, EQEC (+CLEO-Europe) 2003*, Munich, June 2003.
10. N. K. Berger, B. Levit, A. Bekker, and B. Fischer, "Compression of periodic optical pulses using temporal fractional Talbot effect", *European Quantum Electronics Conference, CLEO-Europe (+EQEC) 2003*, Munich, June 2003.
11. Ariel Gordon, Boris Vodonos and Baruch Fischer, "Exact thermodynic-like behavior of pulse formation in mode-locked lasers (exhibiting phase transition, melting and freezing)", *Gordon Research Conference (GRC) on Nonlinear Optics and Lasers*, New London New Hampshire, July 2003.
12. J. Azana, N. K. Berger, B. Levit and B. Fischer, "New and simplified system configuration for temporal imaging of optical pulses"; *The 16th Annual meeting of the IEEE Laser and Electro-Optics Society LEOS 2003*, Tucson, Arizona October 2003.
13. J. Azana, N. K. Berger, B. Levit and B. Fischer, "Spectro-temporal imaging of optical pulses using time lens operation in the spectral Fraunhofer regime", *1st international meeting on Applied Physics*, Badajoz, Spain, October 2003.
14. R. Weill, B. Vodonos, A. Gordon, A. Bekker, V. Smulakovsky, O. Gat and B. Fischer, "Noise dependent buildup of multiple pulses in mode-locked lasers along with a cascade of phase transitions", *Conf. on Lasers and Electro-Optics (CLEO)*, San Francisco 2004.
15. O. Gat, A. Gordon and B. Fischer, "The onset and breakdown of passive mode locking with parabolic spectral filtering", Conf. on Lasers and Electro-Optics (CLEO), San Francisco 2004.
16. N. K. Berger, B. Levit and B. Fischer, "Phase measurement of periodic optical pulses using the temporal Talbot effect", *Conf. on Lasers and Electro-Optics (CLEO)*, San Francisco 2004.
17. N. K. Berger, B. Levit and B. Fischer, "Compensation of spatial dispersion for periodic optical patterns using a quasi-periodic multilayer structure", *Conf. on Lasers and Electro-Optics (CLEO)*, San Francisco 2004.
18. N. K. Berger, B. Levit, V. Smulakovsky and B. Fischer, "Complete characterization of fiber laser pulses using real-time spectral interferometry", *Conf. on Lasers and Electro-Optics (CLEO)*, San Francisco 2004.
19. Gordon, B. Vodonos, O. Gat and Baruch Fischer, "Pulse formation in passive mode locked lasers: a noise induced phase transition"; *Fluctuations and Noise in Photonics and Quantum Optics II*, Gran Canaria, Spain, 2004.
20. J. Azana, N. K. Berger, B. Levit V. Smulakovsky and B. Fischer, "Frequency Shifting of Periodic Microwave Signals Using a General Temporal Self-Imaging (Talbot) Effect in

Optical Fiber"; *Topical Meeting on Microwave Photonics, 2004*, Ogunquite, Maine, USA.

21. N. K. Berger, B. Levit, V. Smulakovsky and B. Fischer, "Characterization of fiber laser pulses using time-domain interferometry", *EPS-QEOD European Conference on Solid-State and Fiber Coherent Light Sources*, Lausanne, Switzerland, 2004.

Moshe Horowitz

Fiber Bragg gratings have revolutionized the fields of optical communications and optical fiber sensing. The direct problem of calculating the spectrum from the grating profile is well understood. Inverse scattering theory (IST) is used to extract the structure of a grating from its complex spectrum. In a synthesis problem, the grating profile is extracted from the desired spectral response. In a sensor IST can be used to develop novel distributed fiber sensors. Although IST in a one dimensional problem was intensively studied in many fields, IST in fiber Bragg gratings offers a new challenge. The high reflectivity of fiber Bragg gratings prevents in many important cases the implementation of methods developed in other fields. Therefore, a direct implementation of IST methods taken from other fields could not solve up to day important problems such as extracting the structure of conventional gratings used in optical communication systems.

In our work we have developed a new method to measure the impulse response of fiber Bragg gratings using low-coherence tomography. The method does not require a slow mechanical scan as needed in other techniques. The measurement technique and the use of Gabor transform enabled to demonstrate novel temperature sensors for studying the temperature increase in high power fiber components. The measurement of the temperature distribution in the device rather than the average temperature enabled to identify the cause for the high temperatures that were measured. We have also demonstrated for the first time a distributed evanescent fiber Bragg sensor with a high spatial resolution.

In our theoretical work we have developed a novel inverse scattering algorithm that allowed us to reconstruct the structure of an arbitrary grating structure. Furthermore, we have shown theoretically that the instability of the inverse scattering algorithms can be overcome. We used our theory as well as novel experimental technique to demonstrate experimentally, for the first time, the reconstruction of a highly reflecting grating. We have also extended the current inverse-scattering algorithms to include the effects of loss and nonlinearities in the fiber. In another part of the research we have demonstrated a novel method that enabled to reconstruct, for the first time, the structure of long period gratings. Such elements are often used in optical communication systems as well as in optical sensors. The inverse scattering theory in long period gratings that was developed in previous works required a very complex measurement. Therefore, the reconstruction of long period gratings has not been demonstrated yet. We have developed a theoretical method for reconstructing the structure of long period gratings from a simple measurement. We used this method to reconstruct, for the first time, the profile of a long period grating from a measurement. We applied our novel theoretical and experimental techniques to develop novel distributed biochemical sensors. Such sensors enable to study novel physical effects as well as to perform many different tests in a small volume. We believe that our theoretical and experimental work will enable to significantly improve the performance of fiber gratings as well as to develop novel fiber sensors.

Graduate Students:

* Shay Keren (Ph.D. Student), ``Broadband fiber lasers and their applications in optical communication systems and in optical tomography'' – completed (Dec 2002).
* Oren Levinson (M.Sc. Student) ``Microwave pulse generation in optical systems`` - completed (Jan 2003).
* Yaron Rabi (M.Sc. Student) ``Optical tomography in scattering media using acousto-optic and Doppler effects'' – completed (March 2003).
* Dolgin (M.Sc. Student) `` Bit-Error Rate calculation in optical communication systems and Its application to develop advanced modulation techniques" – completed (May 2004)
* V. Prosentov (PostDoc) ``Novel fiber lasers and its applications" –completed (Nov. 2004)
* Avi Zeituni (Ph.D. Student), ``Actively modelocked fiber lasers and their applications in optical communication systems and in analog to digital converters''
* Amir Rosenthal (Ph. D. Student) ``Inverse scattering in fiber gratings''.
* E. Levy (M.Sc. Student) ``Inverse Scattering Methods in Anisotropic optical systems."
* Z. Tamir (M.Sc. Student) ''Optical sampling of microwave pulses".

Journal Papers:

1. Y. Mitnick, M. Horowitz and B. Fischer, ``Bistability in cavities with erbium-doped fiber amplifiers due to bidirectional pump-beam interference," J. Opt. Soc. of Am. B, Vol. 14, 2079-83, 1997.
2. M. Horowitz, A.Craplyvy, B. Tkach and J. Zyskind, "Broadband transmitted intensity noise induced by stokes and anti-stokes Brillouin scattering in single-mode fibers," IEEE PTL, Vol 9, 124-126, 1997.
3. M. Horowitz, Y. Barad, and Y. Silberberg, ``Noiselike pulses with a broadband spectrum generated from an erbium-doped fiber laser," Opt. Lett., Vol.22, 799-801, 1997.
4. Y. Barad, H. Eisenbeg, M .Horowitz and Y. Silberberg, ``Nonlinear microscopy based on third harmonic generation,'' Appl. Phys. Lett., Vol. 70, 922-924, 1997.
5. M. Horowitz and Y. Silberberg,``Nonlinear Filtering Using Intensity Dependent Polarization Rotation in Birefringent Fibers,'' Opt. Lett., Vol. 22, 1760-1762, 1997.
6. Bekker, A. Pedael, N.K. Berger, M. Horowitz and B. Fischer, ``Optically induced domain waveguides in SBN crystals,'' Appl. Phys. Lett., Vol. 72, 3121-3123, 1998.
7. Pedael, R. Daisy, M. Horowitz and B. Fischer, ``Beam-coupling induced transparency in Bacteriorhodopsin based saturable absorber," Opt. Lett., Vol. 23, 1173-1175, 1998.

8. Y. Mitnick, M. Horowitz and B. Fischer, ``Wave mixing in periodic pumped optical amplifier," J. Opt. Soc. of Am. B, Vol 15, 2433-2438, 1998.

9. M. Horowitz and Y. Silberberg, ``Control of Noiselike Pulse Generation in Erbium-doped fiber lasers," IEEE PTL, Vol. 10, 1389-1391, 1998.

10. M. Horowitz, C. R. Menyuk, and S. Keren, ``Modeling the saturation induced by broad-band pulses amplified in an erbium-doped fiber amplifier," IEEE Photon. Technol. Lett., Vol. 11, pp. 1235-1237, 1999.

11. M. Horowitz and C. R. Menyuk, ``Analysis of pulse dropout in harmonically modelocked fiber lasers using Lyapunov's method," Opt. Lett., Vol. 25, 40-42, 2000.

12. M. Horowitz, C. R. Menyuk, T. F. Carruthers, and I. N. Duling, ``Pulse dropout in harmonically modelocked fiber lasers," IEEE Photon. Technol. Lett. March, 2000.

13. T. F. Carruther, I. N. Duling, M. Horowitz, and C. R. Menyuk, ``Dispersion management in a harmonically modelocked fiber soliton laser,'' Opt. Lett., Vol. 25, pp. 153-155, 2000.

14. M. Horowitz, C. R. Menyuk, T. F. Carruthers, and I. N. Duling, ``Theoretical and experimental study of harmonically modelocked fiber lasers for optical communication systems", IEEE Journal of Lightwave Technology, Vol. 18, pp. 1565-1574, 2000. **Invited paper.**

15. S. Keren and M. Horowitz, ``Interrogation of fiber gratings using low-coherence spectral Interferometry,'' Opt. Lett., Vol 26, pp. 328-330, 2001.

16. Y. Levy, E. Brand, S. Keren, M. Horowitz, and B. Levit, `` High speed reconstruction of information stored in optical fibers,'' Opt. Lett., Vol 27, pp. 125-127, 2002.

17. Mark Zaacks, Avi Zeitouny, Moshe Horowitz, and Uri Mahlab, ``Measurement Technique of Phase Aberration induced by Fiber Bragg Gratings,'' IEEE Photonics Technology Letters, Vol. 14, pp. 352-354, 2002.

18. V. Goloborodko, S. Keren, and M. Horowitz, ``A new method for measuring temperature changes in high power optical fiber components,'' Applied Optics, Vol.42, pp. 2284-2288, May 2003.

19. O. Levinson and M. Horowitz, ``Generation of complex microwave and millimeter wave pulses using dispersion and Kerr effect in optical fibers,'' IEEE Journal of Lightwave Technology, Vol. 21, pp. 1179-1187, May 2003.

20. S. Keren, A. Rosenthal, and M. Horowitz, ``Measuring the structure of highly reflecting fiber Bragg gratings,'' IEEE Photonics Technology Letters, Vol. 15, pp. 575-577, 2003.

21. Rosenthal and M. Horowitz, ``Inverse scattering algorithm for reconstructing strongly reflecting fiber Bragg gratings,'' IEEE J. Quantum Electronics, Vol. 39, pp. 1018-1026, Aug. 2003.

22. S. Keren and M. Horowitz, `` Distributed 3-D Fiber Bragg grating refractometer for biochemical sensing," Opt. Lett., Vol. 28, pp. 2037-2039, 2003.

23. M. Zaacks, U. Mahlab, M. Horowitz, and S. Stepanov, ``Online Measuring The Dispersion Sign in Optical Communication Systems," Electron. Lett. Vol. 39, pp. 1198-9, 2003.
24. Rosenthal and M. Horowitz**,** `` Inverse scattering algorithm for reconstructing lossy fiber Bragg gratings,'' *J. Opt. Soc. of Am. A*, 21: 552–560, 2004.
25. Y. Rabi, S. Stepanov, M. Horowitz, and B. Spektor, "Optical imaging using a directional detector," *J. Opt. Soc. of Am. A*, 21: 707–712, 2004.

Conferences:

1. Rosenthal, S. Keren, and M. Horowitz, "Measuring the structure of highly reflecting fiber Bragg gratings", in the conference on *Optical Fiber Communication (OFC)*, Atlanta, March 2003.
2. S. Keren, V. Goloborodko, A. Rosenthal, B. Levit, M. Horowitz, "Temperature profile measurement in high power optical fiber components using a distributed fiber sensor", in the *Conference on Lasers and Electro-Optics (CLEO)*, Baltimore, Maryland, June 2003.
3. Rosenthal, S. Keren, and M. Horowitz, "Measuring the structure of highly reflecting fiber Bragg gratings", in the *Conference on Lasers and Electro-Optics (CLEO)*, Baltimore, Maryland, June 2003.
4. Rosenthal, and M. Horowitz, "A new inverse scattering algorithm for reconstructing highly reflecting fiber Bragg gratings", in the *Conference on Lasers and Electro-Optics (CLEO)*, Baltimore, Maryland, June 2003.
5. Rosenthal, and M. Horowitz, "Inverse scattering algorithm for reconstructing the loss/gain profile in fiber Bragg gratings," Postdeadline Paper, in *Bragg Gratings, Photosensitivity, and Poling in Glass Waveguides*, Monterey, California, September 2003.

Ron Meir

Recent Research Interests:

- Improved data-dependent generalization error bounds for machine learning
- Theory of multi-category pattern classification
- Feature extraction and dimensionality reduction
- Automated analysis and classification of microscopic biopsy images
- Information processing, computation and learning in networks of biological neurons

Graduate Students:

Completed Theses: M.Sc.

* Arik Azran: Data-dependent risk bounds and algorithms for hierarchical mixture of experts classifiers.
* Shay Ben-David: Time Series Prediction Using Mixtures of Experts.
* Shimon Benjo, Performance analysis for mixture classifiers using local methods.
* Rachel Genusov: Three-dimensional Image Compression (with Prof. R. Kimmel).
* Omri Gutman,: Classification Using Projections onto a Single Dimension
* George Leifman: Determining similarity between tree-dimensional objects using relevance feedback (with Dr. A. Tal).
* Haggit Sandhaus: Localization of activity sources in the brain using independent component analysis (with Prof. H. Pratt) & 6/03.

Completed Theses: Ph.D.

* Amir Karniel: Learning Motion Control of Redundant Systems, Primary advisor: Prof. Gideon Inbar.

Theses in progress: M.Sc.

* Dorit Barash: Policy learning in reinforcement learning and possible implications to biological systems.
* Ilya Desyatnikov: On the Optimal Selection of Coding Matrices for Multi-Category Classification.
* Dotan Di Castro: Methods for extracting biological network structure and functionality from network dynamical behavior.
* Eyal Levanoni: Mixture of auto-regressive models for time series modelling.
* Ayelet Sorek: A network model of the middle 4C layer in the monkey's V1 area.
* Igor Zingman: Detection of regions of interest in medical images.

Theses in progress: Ph.D.

* Dori Peleg: Feature selection for kernel methods.

Refereed Journal Papers:

1. R. Meir, ``Finite Sample Bounds for Time Series Prediction'', Phil. Mag. B, 77(5): 1585-1591, 1998.
2. A. Zeevi, R. Meir and V. Maiorov, ``Error Bounds for Functional Approximation and Estimation Using Mixtures of Experts'', IEEE Trans. Inf. Theory, 44(3): 1010-1025, May 1998.
3. P. Bartlett, V. Maiorov and R. Meir, ``Almost Linear VC Dimension Bounds for Piecwise Polynomial Networks'', Neural Computation, 10(8): 2159-2173, 1998.
4. V. Maiorov and R. Meir, ``Approximation Bounds for Smooth Functions in {\bf C}$(\Re^d)$ by Neural and Mixture Networks'', IEEE Trans. Neural Networks, 9(5):969-978, September 1998.
5. V. Maiorov, R. Meir and J. Ratsaby, ``On the Approximation of Functional Classes Equipped with a Uniform Measure using Ridge Functions'', J. of Approx. Theory, 99:95-111, 1999.
6. R. Meir and V. Maiorov, ``Distortion bounds for vector quantizers with finite codebook size'', IEEE. Trans. Inf. Theory, 45(5):1621-1631, 1999.
7. R. Meir, ``Nonparametric Time Series Prediction Through Adaptive Model Selection'', Machine Learning, 39:5-34, 2000.
8. V. Maiorov and R. Meir, ``On the Near Optimality of the Stochastic Approximation of Smooth Functions by Neural Networks'', Advances in Computational Mathematics, 13(1):79-103, 2000.
9. R. Meir and V. Maiorov, ``On the Optimality of Neural Network Approximation Using Incremental Algorithms', IEEE. Trans. Neural Networks, 11(2):323-337, 2000.
10. A. Karniel, R. Meir and G. Inbar, ``Polyhedral Mixture of Linear Experts for Many-to-One Mapping Inversion and Multiple Controllers'', Neurocomputing 37(1-4): 31-49, 2001.
11. V. Maiorov and R. Meir, ``Lower bounds for multivariate approximation by affine-invariant dictionaries'', IEEE Transactions on Information Theory, 47(4): 1569 -1575, 2001.
12. A. Karniel, R. Meir and G. F Inbar, ``Best Estimated Inverse versus Inverse of the Best Estimator'', Neural Networks, 14:1153-1159, 2001.
13. S. Mannor and R. Meir, ``On the Existence of Weak Learners and Applications to Boosting'', Machine Learning, 48: 219-251, 2002.
14. R. Meir and G. Rätsch, ``An Introduction to Boosting and Leveraging'', in Advanced Lectures on Machine Learning, 119-184, Eds. S.~Mendelson and A.~Smola, Springer 2003.
15. S. Mannor, R. Meir and T. Zhang, “Greedy Algorithms for Classification - Consistency, Convergence Rates, and Adaptivity”, Journal of Machine Learning Research, 4:713-741, 2003.
16. R. Meir and T. Zhang, “Generalization Error Bounds for Bayesian Mixture Algorithms”, Journal of Machine Learning Research, 4:839-860, 2003.
17. Y. Engel, S. Mannor and R. Meir, “The Kernel Recursive Least-Squares Algorithm”, IEEE Tran. Signal Processing, 2004, 52(8): 2275-2285.
18. P. Derbeko, R. El-Yaniv and R. Meir, “Explicit Learning Curves for Transduction and Application to Clustering and Compression Algorithms”, Journal of Artificial Intelligence Research 2004, 22:117-142.

19. D. Peleg and R. Meir, “Feature Selection by Global Minimization of a Generalization Bound”, Submitted to Journal of Machine Learning Research, January 2005.

Book Chapters:

R. Meir and G. Rätsch, “An Introduction to Boosting and Leveraging”, in Advanced Lectures on Machine Learning, 119-184, Eds. S. Mendelson and A. Smola, Springer 2003.

Fully Refereed Conference Publications:

1. R. Meir, ``Structural Risk Minimization for Time Series Prediction'' in Advances in Neural Information Processing Systems 10, Ed. S. Solla, pp. 308-314, MIT Press 1998.
2. A. Karniel, R. Meir and G. Inbar, ``Polyhedral mixture of linear experts for many-to-one mapping inversion'', in Proceedings of the European Symposium on Neural Networks - ESANN'98, Ed. M. Verleysen, pp. 155-160, D-Facto publications 1998.
3. R. Meir and V. Maiorov, ``Stochastic Approximation by Neural Networks Using the Radon and Wavelet Transforms'', in Proceedings of the 1998 IEEE Workshop on Neural Networks for Signal Processing, Ed. M. Niranjan, E. Wilson, T. Constantinidis and S.Y. Kung, pp. 224-233, IEEE Press 1998.
4. R. Meir and V. Maiorov, ``On the Optimality of Incremental Neural Network Algorithms'', in Advances in Neural Information Processing Systems 11, MIT Press 1999.
5. P. Bartlett, R. Meir and V. Maiorov, ``Almost Linear VC Dimension Bounds for Piecewise Polynomial Networks'', in Advances in Neural Information Processing Systems 11, MIT Press 1999.
6. A. Karniel, R. Meir and G. Inbar, ``Exploiting the virtue of redundancy'', in International Joint Conference on Neural Networks, 1999.
7. O. Golan, M. Idan and R. Meir, ``A Non-Model Based Analytical Detection of an Abrupt Change Fault in Flight Control Systems'', 40th Israel Annual Conference on Aerospace Sciences, 2000.
8. O. Golan, M. Idan and R. Meir, ``Weak Model Based Fault Detection and Identification in Flight Control Systems'', Proceedings of the 8th Mediterranean Conference on Control and Automation (MED 2000).
9. A. Karniel, R. Meir and G.F. Inbar ``A Two-Way Model for Motor Control of Redundant Systems'', CD-ROM Proceedings of the World Congress on Medical Physics and Biomedical Engineering Chicago, 4 pp., July 23-28, 2000.
10. O. Golan, M. Idan and R. Meir, ``Weak model based approach for fault detection and isolation of sensors in flight control systems'', Proceedings of the AIAA Guidance, Navigation, and Control Conference, 2000.
11. R. Meir and R. El-Yaniv and S. Ben-David, ``Localized boosting'', Proc. Thirteenth Annual Conference on Computational Learning Theory 2000, Eds. N. Cesa-Bianchi and S. Goldman, pp. 190-199, Morgan Kaufman.
12. S. Mannor and R. Meir, ``Weak Learners and Improved Rates of Convergence in Boosting'', in Advances in Neural Information Processing Systems 13, MIT Press 2001.

13. S. Mannor and R. Meir, ``Geometric bounds for generalization in boosting", Proc. Fourteenth Annual Conference on Computational Learning Theory 2001, Eds. D. Helmbold & B. Williamson, Springer Verlag.

14. S. Mannor, R. Meir and T. Zhang, ``The consistency of greedy algorithms for classification", Proc. Fifteenth Annual Conference on Computational Learning Theory 2002, Eds. J. Kivinen and & R. Sloan, Springer Verlag.

15. Y. Engel, S. Mannor, R. Meir, ``Sparse Online Greedy Kernel Regression Algorithms", Proc. 13th European Conference on Machine Learning 2002

16. P. Derbeko, R. El-Yaniv and R. Meir, ``Variance Optimized Bagging", Proc. 13th European Conference on Machine Learning 2002

17. R. Meir and T. Zhang, "Data-Dependent Bounds for Bayesian Mixture Methods", in *Advances in Neural Information Processing Systems 15*, MIT Press 2003.

18. G. Leifman, S. Katz, A. Tal, Ron Meir, "Signatures of 3D Models for Retrieval", Proc. of the The 4th Israel-Korea Bi-National Conference on Geometric Modeling and Computer Graphics 2003, pp. 159-163.

19. Y. Engel, S. Mannor and R. Meir, "Bayes Meets Bellman: The Gaussian Process Approach to Temporal Difference Learning", Proc. of the Twentieth International Conference on Machine Learning (ICML-2003).

20. Desyatnikov and R Meir, "Data-Dependent Bounds for Multi-Category Classification Based on Convex Losses", Proc. Sixteenth Annual Conference on Computational Learning Theory (COLT - 2003).

21. M. Nisenson, I. Yariv, R. El-Yaniv and R. Meir, "Towards Behaviometric Security Systems: Learning to Identify a Typist", Proc. of the 14th European Conference on Machine Learning (ECML-2003).

22. P. Derbeko, R. El-Yaniv and R. Meir, "Error Bounds for Transductive Learning via Compression and Clustering", in *Advances in Neural Information Processing Systems 16*, MIT Press 2003. Relevance Feedback for 3D Shape Retrieval.

23. G. Leifman, R. Meir and A. Tal, "Relevance Feedback for 3D Shape Retrieval", The 5th Israel-Korea Bi-National Conference on Geometric Modeling and Computer Graphics, October 2004.

24. Azran and R. Meir, "Data Dependent Risk Bounds For Hierarchical Mixture of Experts Classifiers", Proc. Seventeenth Annual Conference on Computational Learning Theory (COLT - 2004).

25. D. Peleg and R. Meir, "A feature selection algorithm based on the global minimization of a generalization error bound", in *Advances in Neural Information Processing Systems 17*, MIT Press 2005.

Moshe Porat

Recent Research Interests:

- Signal and Image Processing
- Computer Vision
- Biological Visual and Auditory Systems
- Medical Imaging
- Sampling
- Time-Frequency Representations
- Multimedia
- Image and Video Compression

Recent Graduate Students:

* Sharon Urieli - Image Analysis and Representation by Spectral Phase.
* Amir Francos - Signal Analysis and Synthesis using Positive Time-Frequency.
* Gal Shachor - Signal Reconstruction from Partial Information in the Position Frequency Space. Distributions.
* Yossi Shapiro - Signal Reconstruction from Spectral Amplitude.
* Nir Brueller - Non-Uniform Sampling of Signals with Time varying Characteristics.
* Larisa Goffman-Vinopal - The Effect of Intercolor Correlation on Color Image Compression.
* Ari Shenhar - Processing of Spatial Distortions in Images.
* Gil Michael - On Signal Reconstruction from Fourier Magnitude.
* Dmitry Furman - Compression of Video Sequences using Three Dimensional Vector Quantization.
* Elad Klein - Model Order Selection for Harmonic Signals by Super Resolution Methods.
* Xiao Qiong Tang - On Special Signals in Image Reconstruction from Partial Spectral Information.
* Lior Assouline- On Quality Criteria for Time-Varying Filtering.
* Don Chen - Diamond evaluation using Computer Vision Tools, with G. CogHill.
* Amir Leventer - On Optimal Bit Rate Reduction in Video Coding.
* Yair Kerner - Quality enhancement of ultrasound imaging using compounding.
* Sharon Harell - Development of a computerized approach for quantitative analysis of the 'Myocardial Blush Grade' in patients undergoing angiography, Primary adviser R. Beyar (in progress).
* Yalon Roterman - Color image coding using regional correlation of primary colors.
* Emilia Burlak - Correlation vs. Decorrelation of Color Components in Image Compression (in progress).
* Hagai Kirshner - On sampling-invariant charecteristics in signal representation (in progress).
* Orly Feldman - Tracking of strong reflectors in consecutive myocardial ultrasound RF images following pre-processing of the RF lines. Primary adviser D. Adam (in progress).
* Evgeny Gershikov - Video compression using inter-color correlation (in progress).
* Ronen Sher - Super Resolution using Statistical Models (in progress).

* Roni Mittelman - On Multi-Resolution Statistical Models for Image Processing (in progress).
* Ziv Mizrahi - On Depth Information in Images (in progress).

Recent Publications:

1. H. Kirshner and M. Porat, "A New Approach to Sampling Finite Energy Functions and Sobolev Signal Representation", accepted to SampTA05 International Conference, July 2005.
2. H. Kirshner and M. Porat, "From Analog Information to Digital Databases - Does It Keep Everything Intact?", The Thirteenth International Conference on Information Systems Development, ISD'04, September 2004.
3. M. Porat, "On Coding and Codebooks in Multimedia Information Systems", The Thirteenth International Conference on Information Systems Development, ISD'04, September 2004.
4. Yalon Roterman and Moshe Porat, "Content-Based Compression in Aerial Imaging using Inter-Color Correlation", the Int'l Symposium on Photogrammetry and Remote Sensing (ISPRS), July 2004.
5. L. Assouline and M. Porat, "Toward Optimal Linear Time-Varying Filtering", The Int'l conference IEEE OPTIM 2004, pp. 131-138, May 2004.
6. Y. Kerner and M. Porat, "A Maximum Likelihood Approach to Optimal Ultrasound Imaging Using Spatial Compounding", The Int'l conference IEEE OPTIM 2004, pp. 139-146, May 2004.
7. S. Harell, R. Beyar, L. Gruberg and M. Porat, "On Computer-Vision Approach to Quantitative Analysis of the Myocardial Blush Grade in Patients Undergoing Angioplasty", The International Symposium on Bio-Inspired Engineering (2003).
8. M. Porat, "Image Reconstruction from Fourier Information in Biological and Machine Vision", The International Symposium on Bio-Inspired Engineering (2003).
9. D. Furman and M. Porat, "On Content-Based Very Low Bitrate Video Coding", The VLBV Conference, Madrid (2003).
10. Leventer and M. Porat, "Towards Optimal Bit-Rate Control in Video Transcoding", IEEE International Conference on Image Processing, ICIP'03, Barcelona (2003).
11. Yalon Roterman and Moshe Porat, "Progressive Image Coding using Regional Color Correlation", the 4th EURASIP Conference, Zagreb (2003).
12. Leventer and M. Porat, "On Bit Allocation in Video Coding and Transcoding", IEE International Conference on Visual Information Engineering - VIE 2003, Guildford, UK (2003).
13. S. Tang, A. Bigdeli, M. Porat and Z. Salcic, "Control of Temporal Speed in Video Sequences", IEEE Tencon'02, Beijing China (2002).
14. Larisa Goffman-Vinopal and Moshe Porat, "Color Image Compression using Inter-color Correlation", IEEE International Conference on Image Processing ICIP-2002, Rochester, NY (2002).
15. Xiao Qiong Tang and Moshe Porat, "Complex-Valued Image Reconstruction from Spectral Phase or Magnitude", SPIE International conference on Image Reconstruction from Incomplete Data, Seattle (2002).

16. L. Assouline and M. Porat, "On Linear Time-Varying Filtering - Quality Criteria", The SCI'02 World Multiconference on Systemics, Cybernetics, and Informatics (2002).
17. D. Furman and M. Porat, "On Three-Dimensional DCT-Based Video Compression using Activity Maps", SPIE International Symposium on Electronic Imaging, San Jose, California (2002).
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19. D. Furman and M. Porat, "Video Compression in the Cosine Time-Spatial Domain using Human Vision Characteristics", IAPR/IEEE Conference on Image and Vision Computing, New Zealand IVCNZ'01, pp. 333-337 (2001).
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21. G. Michael and M. Porat "On signal reconstruction from Fourier Magnitude", IEEE International Conference ICECS, Malta (2001).
22. M. Porat, "Localized Video Compression for Machine Vision", The Robot Vision Workshop, Auckland LNCS No. 1998, Klette et al. (Eds), pp. 278-283 (2001).
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24. M. Porat, "Model-Based Approach to Video Perception and Motion", ECVP 2000, Groningen, The Netherlands (2000).
25. L. Alfandary, L. Binyamini, Y. Shapiro and M. Porat "Signed Spectral Amplitude: Unique Representation and Image Restoration", ACIVS 2000, Baden-Baden, Germany (2000).
26. M. Porat, "Video Coding using Vector Quantization", ACIVS 2000, Baden-Baden, Germany (2000).
27. M. Porat, "Image Reconstruction from Partial Information", Dagstuhl Seminar on Multi-Image Search, Filtering, Reasoning and Visualisation, Germany (2000).
28. M. Porat, "Localized Processing in Vision and Image Computing", The German-Israeli Ollendorff Symposium on Image Processing and Computer Vision (2000).
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30. Francos and M. Porat, "Analysis and Synthesis of Multicomponent Signals using Positive Time-Frequency Distributions", IEEE Trans. on Signal Processing, Vol. 47, No. 2, pp. 493-504 (1999) .
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34. R. E. Shenhar and M. Porat, "Adaptive Non-Linear Processing in Ultrasound Imaging", IEEE International conference on WISP, pp. 83-86, Budapest (1999).
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2. L. Goffman-Vinopal and M. Porat, "On Compression Systems for Color Images", *IEEE International Conference ICECS*, Dubrovnik, 2002.
3. X.-Q. Tang and M. Porat, "Complex-Valued Image Reconstruction from Spectral Phase or Magnitude", *SPIE International conference on Image Reconstruction from Incomplete Data*, Seattle, 2002.
4. S. Tang, A. Bigdeli, M. Porat and Z. Salcic, "On Temporal Span Scalability of Video Sequences", *IEEE Tencon'02*, Beijing China, October 2002.
5. L. Goffman-Vinopal and M. Porat, "Color Image Compression using Inter-color Correlation", *IEEE International Conference on Image Processing ICIP-2002*, Rochester, NY (September, 2002).
6. Y. Roterman and Moshe Porat, "Progressive Image Coding using Regional Color Correlation", *4th EURASIP Conference*, Zagreb (2003).
7. Leventer and M. Porat, "On Bit Allocation in Video Coding and Transcoding", *IEE International Conference on Visual Information Engineering - VIE 2003*, Guildford, UK (2003).
8. D. Furman and M. Porat, "On Content-Based Very Low Bitrate Video Codind", *VLBV Conference*, Madrid (2003)
9. Leventer and M. Porat, "Towards Optimal Bit-Rate Control in Video Transcoding", *IEEE International Conference on Image Processing, ICIP'03*, Barcelona (2003).
10. S. Harell, R. Beyar, L. Gruberg and M. Porat, "On Computer-Vision Approach to Quantitative Analysis of the Myocardial Blush Grade in Patients Undergoing Angioplasty", *The International Symposium on Bio-Inspired Engineering (2003)*.
11. M. Porat, "Image Reconstruction from Fourier Information in Biological and Machine Vision", *The International Symposium on Bio-Inspired Engineering (2003)*.

12. Y. Roterman and M. Porat, “Content-Based Compression in Aerial Imaging using Inter-Color Correlation”, *Int’l Symposium on Photogrammetry and Remote Sensing (ISPRS)*, July 2004.
13. L. Assouline and M. Porat, “Toward Optimal Linear Time-Varying Filtering”, *The Int'l conference IEEE OPTIM 2004*, pp. 131–138, 2004.
14. Y. Kerner and M. Porat, “A Maximum Likelihood Approach to Optimal Ultrasound Imaging Using Spatial Compounding”, *The Int'l conference IEEE OPTIM 2004*, pp. 139–146, 2004.
15. H. Kirshner and M. Porat, “From Analog Information to Digital Databases – Does It Keep Everything Intact?” *The Thirteenth International Conference on Information Systems Development, ISD'04*, September 2004.
16. M. Porat, “On Coding and Codebooks in Multimedia Information Systems”, *The Thirteenth International Conference on Information Systems Development, ISD'04*, September 2004.

Yoav Schechner

Recent Research Interests:

- Uncontrolled modulation imaging for obtaining high dynamic range and multispectral images.
- Underwater computer vision.
- Multiplexing approaches in illumination.
- 3D imaging in optical microscopy using novel optical components.
- Radiometric calibration via image mosaics.
- Independent component analysis.

Journal Papers:

1. S. Shwartz, M. Zibulevsky and Y. Y. Schechner, *"Fast kernel entropy estimation and optimization,"* To be published in Signal Processing, Special Issue on *Information Theoretic Signal Processing* (2005).
2. Y. Y. Schechner and S. K. Nayar, *"Generalized mosaicing: Polarization panorama,"* To be published in IEEE Trans. Pattern Analysis & Machine Intelligence (2005).
3. Litvinov and Y. Y. Schechner, *"A radiometric framework for image mosaicing,"* To be published in the Journal of the Optical Society of America -A (2005).
4. Y. Y. Schechner and N. Karpel, *"Recovery of underwater visibility and structure by polarization analysis,"* Submitted (2004).
5. Y. Y. Schechner and N. Kiryati, ``*Depth from defocus vs. Stereo: How different really are they?''* International Journal of Computer Vision **39**, pp. 141-162 (2000).

5. Y. Y. Schechner, N. Kiryati and R. Basri, ``*Separation of transparent layers using focus,''* International Journal of Computer Vision **39**, pp. 25-39 (2000).
6. Y. Y. Schechner, J. Shamir and N. Kiryati, ``*Polarization and statistical analysis of scenes containing a semi-reflector,''* Journal of the Optical Society of America - A **17**, pp. 276-284 (2000).
7. R. Piestun, Y. Y. Schechner and J. Shamir, ``*Propagation invariant wave-fields with finite energy,''* Journal of the Optical Society of America - A **17**, pp. 294-303 (2000).
8. Y. Y. Schechner, J. Shamir and N. Kiryati, ``*Vision through semi-reflecting media: Polarization analysis,''* Optics Letters **24**, pp. 1088-1090 (1999).

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1. Y. Y. Schechner and S. K. Nayar, "A theory of multiplexed illumination," *Proc. IEEE ICCV International Conference on Computer Vision*, 2003.
2. Y. Y. Schechner and S. K. Nayar, "Polarization mosaicking: High dynamic range and polarization imaging in a wide field of view," *Proc. SPIE* Vol. 5158, *Polarization Science and Remote Sensing*, 2003.
3. Y. Y. Schechner, S. K. Nayar, and P. N. Belhumeur, "A theory of multiplexed illumination," *Proc. IEEE Int. Conference on Computer Vision*, Vol. 2, pp. 808–815, 2003.

4. Y. Y. Schechner and N. Karpel, "Clear underwater vision," *Proc. IEEE Computer Vision and Pattern Recognition*, Vol. I, 2004.
5. Y. Y. Schechner and S. K. Nayar, "Uncontrolled modulation imaging," *Proc. IEEE Computer Vision and Pattern Recognition*, Vol. II, 2004.
6. N. Karpel and Y. Y. Schechner, "Portable polarimetric underwater imaging system with a linear response", *Proc. SPIE 5432: Polarization: Measurement, analysis and remote sensing* VI, 2004.
7. S. Shwartz, M. Zibulevsky and Y. Y. Schechner, "ICA using kernel entropy estimation with NlogN complexity", *Proc. ICA International Conference on Independent Component Analysis and Blind Signal Separation*, 2004.
8. Y. Y. Schechner, S. K. Nayar, P. N. Belhumeur and H. S. Peri, "Imaging in multiplexed illumination," *SPIE 5529: Nonimaging optics and effcient illumination systems*, 2004.

Nir Sochen

Recent Research Interests:

- Applications of Differential Geometry ideas and techniques in Image Processing and Analysis and in Computational Vision.

Graduate Students:

Ph.D. Students:

* Lorina Dascal
* Rami Ben-Ari
* Leah Bar (Joint with Prof. N. Kiryati)
* Ron Peled

M.Sc. Students:

* Ofer Pasternak:
* Yaron Gvili

Former Students:

* Adee Ran (M.Sc. 2000):
* Ran Kaftory (M.Sc. 2002) joint with Prof. Y.Y. Zeevi

Book Chapters:

1. A. Spira, N. Sochen and R. Kimmel , "Geometric Filters, Diffusion Flows, and Kernels in Image Processing", in "Handbook of Computational Geometry for Pattern Recognition, Computer Vision, Neurocomputing and Robotics", Eduardo Bayro-Corrochano (ed.), Springer Verlag, to be published.

Journal Papers:

Published (and Accepted) Articles:

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2. K. Bardakci, L. M. Bernardo and N. Sochen, "Integrable Generalized Thirring Models", Nucl. Phys. B 487 (1997) 513-525.
3. N. Sochen, R. Kimmel and R. Malladi, "A General Framework for Low Level Vision", IEEE Trans. in Image Processing, Special Issue on Geometry Driven Diffusion, 7:310-318, 1998.
4. R. Kimmel, R. Malladi and N. Sochen, "Images as Embedded Maps and Minimal Surfaces: Movies, Color, Texture, and Volumetric Medical Images", International Journal of Computer Vision, 39:111-129, 2000.
5. R. Kimmel and N. Sochen, "Orientation Diffusion or How to Comb a Porcupine", Journal of Visual Communication and Image Representation, 13:238-248, 2001.

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7. G. Gilboa, N. Sochen and Y. Y. Zeevi, “Forward-and-Backward Diffusion Processes for Adaptive Image Enhancement and Denoising”, IEEE Transactions on Image Processing, 11(7):689-703, 2002.
8. A. Brook, R. Kimmel and N. Sochen, “Variational Segmentation for Color Images”, Journal of Mathematical Imaging and Vision, 18(3):247-268, 2003.
9. N. Sochen, “Affine Invariant Flows via the Beltrami Framework”, Journal of Mathematical Imaging and Vision, 20:133-145, 2004.
10. G. Gilboa, N. Sochen and Y. Y. Zeevi, “Image Sharpening by Flows based on Triple Well Potentials”, Journal of Mathematical Imaging and Vision, 20:121-131, 2004.
11. N. Sochen, C. Sagiv and Ron Kimmel, “Stereographic Combing a Porcupine or Studies on Orientation Diffusion”, SIAM Journal on Applied Mathematics, Accepted 2004.
12. G. Gilboa, N. Sochen and Y. Y. Zeevi, “Image Enhancement and Denoising by Complex Diffusion Processes”, IEEE Trans. on Pattern Analysis and Machine Intelligence, Accepted 2004.
13. A. Tankus, N. Sochen and Y. Yeshurun, “Shape-from-Shading under Perspective Projection”, International Journal of Computer Vision, Accepted 2004
14. L. Dascal and N. Sochen, “On the Maximum Principle of the Color Beltrami Flow”, SIAM Journal on Applied Mathematics, Accepted 2004.
15. C. Sagiv, N. Sochen and Y. Y. Zeevi, “Gabor Space Geodesic Active Contours”, IEEE Trans. on Image Processing, Accepted 2004.

Conferences:

1. N. Sochen and Y. Y. Zeevi, “Representation of Images by Surfaces and Higher Dimensional Manifolds in Non-Euclidean Space”, March 97, the 4th International conference on Curves and Surfaces 97.
2. R. Kimmel, N. Sochen and R. Malladi, “Images as Embedding Maps and Minimal Surfaces: A Unified Approach for Image Diffusion", Jan. 97, ICIP97.
3. N. Sochen, Y. Y. Zeevi, “Representation of Colored Images by Manifolds Embedded in Higher Dimensional Non-Euclidean Space”, Jan. 98, ICIP98.
4. N. Sochen, Y. Y. Zeevi, “Resolution Enhancement of Colored Images by Inverse Diffusion Processes”, Oct. 97, ICASSP98.
5. R. Kimmel, R. Malladi and N. Sochen, “Image Processing via the Beltrami Operator”, Sep.97, ACCV 98.
6. N. Sochen, R. M. Haralick and Y. Y. Zeevi, “Geometric Functional for Gradient Estimation”, the 2nd International conference on Scale-Space, Korfu, Greece, March 99.
7. R. Kimmel and N. Sochen, “Geometric-Variational Approach for Color Image Segmentation”, the 2nd International conference on Scale-Space, Korfu, Greece, March 99.
8. R. Kimmel, N. Sochen and R. Malladi, “The Geometry of Texture”, Curves and Surfaces 99, St-Malo, France, March99.

9. N. Sochen, Y. Y. Zeevi, “Color Space Geometry via the Beltrami Framework”, Sep. 98, ICASSP99.
10. N. Sochen, G. Gilboa and Y. Y. Zeevi, “Color Image Enhancement by a Forward-and-Backward Adaptive Beltrami Flow” AFPAC'00, Kiel Germany, Sep.2000.
11. G. Gilboa, Y. Y. Zeevi and N. Sochen, “Signal and Image Enhancement by a generalyzed forward and Bacward adaptive diffusion process”, EUSIPCO-2000, Finland, Sep. 2000.
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14. C. Sagiv, N. Sochen, and Y. Y. Zeevi, ``Gabor Feature Space Diffusion via the Minimal Weighted Area Method" EMMCVPR, INRIA Sophia-Antipolis, France, September 2001.
15. N. Sochen, “Stochastic Processes in Vision: From Langevin to Beltrami” International Conference on Computer Vision '01, Vancouver, Canada, July 2001.
16. N. Sochen, “On Affine Invariance in the Beltrami Framework for Vision” Variational and Level Set Methods '01, Vancouver, Canada, July 2001.
17. C. Sagiv, N. Sochen, and Y. Y. Zeevi, ``Geodesic Active Contours Applied to Texture Feature Space" Scale-Space '01, Vancouver, Canada, July 2001.
18. G. Gilboa, Y. Y. Zeevi and N. Sochen, Resolution Enhancement by Forward-and-Backward Nonlinear Diffusion Processes, Nonlinear Signal and Image Processing, Baltimore, Maryland, June 2001.
19. G. Gilboa, Y. Y. Zeevi and N. Sochen, Complex Diffusion Processes for Image Filtering, Scale-Space '01, Vancouver, Canada, July 2001.
20. G. Gilboa, Y. Y. Zeevi and N.Sochen, Image Enhancement Segmentation and Denoising by Time Dependent Nonlinear Diffusion Processes, ICIP-'01, Thessaloniki, Greece, October, 2001.
21. R. Kimmel and N. Sochen, Using the Beltrami Framework for Orientation Diffusion in Image Processing, 4th International Workshop on Visual Form, Capri, Italy, May 2001.
22. G. Gilboa, N. Sochen and Y. Y. Zeevi , “Regularized Shock Filters and Complex Diffusion”, ECCV02, Copenhagen, Denemark, May 2002.
23. C. Sagiv, N. Sochen, and Y. Y. Zeevi, “Texture Segmentation via a Diffusion-Segmentation Scheme in the Gabor Feature Space”, Texture02, Copenhagen, Denemark, May 2002.
24. G. Gilboa, N. Sochen, Y. Y. Zeevi , “Texture Preserving Variational Denoising Using an Adaptive Fidelity Term”, in Proceedings of the 2nd International Workshop on Variational, Geometry and Level Set Methods in Computer Vision, Nice, France 2003.
25. R. Kaftory, N. Sochen and Y.Y. Zeevi, “Color Blind Deconvolution via the Beltrami Operator”, in Proceedings of the International Symposium on Image and Signal Processing and Analysis, Rome, Italy 2003.
26. Tankus, N. Sochen and H. Yeshurun, “A New Perspective [On] Shape from Shading”, in Proceedings of the International Conference on Computer Vision, Nice, France 2003.

27. G. Gilboa, N. Sochen and Y.Y. Zeevi, “PDE-based Denoising of Complex Scenes using a Spatially-Varying Fidelity Term”, in Proceedings of the International Conference Image Processing, Barcelona, Spain 2003.
28. N. Sochen, R. Deriche and L. Perez-Lopez , “Variational Beltrami Flow Over Implicit Manifolds”, in Proceedings of the International Conference Image Processing, Barcelona, Spain 2003.
29. N. Sochen, R. Deriche and L. Perez-Lopez , “The Beltrami Flow Over Implicit Manifolds”, in Proceedings of the International Conference on Computer Vision, Nice, France 2003.
30. Spira, R. Kimmel and N. Sochen, “Efficient Beltrami Flow Using a Short-Time Kernel” in Proceedings of the 4th International Conference on Scale-Space Methods in Computer Vision, Isle of Skye, Scotland 2003.
31. D. Cremers, C. Schnörr and N. Sochen , “Towards Recognition-based Variational Segmentation using Shape Priors and Dynamic Labelling” in Proceedings of the 4th International Conference on Scale-Space Methods in Computer Vision, Isle of Skye, Scotland 2003.
32. L. Dascal and N. Sochen, “On the Maximum Principle of the Color Beltrami Flow”, in Proceedings of the 4th International Conference on Scale-Space Methods in Computer Vision, Isle of Skye, Scotland 2003.
33. Y. Gvili and N. Sochen, ``A Complete System of Measuring Invariants'', in Proceedings of the 4th International Conference on Scale-Space Methods in Computer Vision, Isle of Skye, Scotland 2003.
34. R. Ben-Ari and N. Sochen , “Non-Isotropic Regularization of the Correspondence Space in Stereo-Vision”, in Proceedings of the International Conference on Pattern Recognition, Cambridge, England 2004.
35. M. Feigin and N. Sochen, “Segmentation and Denoising via an Adaptive Threshold Mumford-Shah-like Functional”, in Proceedings of the International Conference on Pattern Recognition, Cambridge, England 2004.
36. Tankus, N. Sochen and H. Yeshurun, “Reconstruction of Medical Images by Perspective Shape from Shading”, in Proceedings of the International Conference on Pattern Recognition, Cambridge, England 2004.
37. Tankus, N. Sochen and H. Yeshurun, “Perspective Shape from Shading by Fast Marching”, in Proceedings of the International Conference on Computer Vision and Pattern Recognition, Washington DC, USA 2004.
38. O.Pasternak, N. Sochen and Y. Asaf, “Separation of White Matter Fascicles From Diffusion MRI Using Phi-Functional Regularization”, in Proceedings of the International Symposium on Magnetic Resonance in Medicine, Kyoto, Japan 2004.
39. L. Bar, N. Sochen and N. Kiryati, “Variational Pairing of Image Segmentation and Blind Restoration”, in Proceedings of the European Conference on Computer Vision, Prague, Czech Republic 2004.
40. T. Riklin-Raviv, N. Sochen and N. Kiryati, “Unlevel-Sets: Geometry and Prior-based Segmentation”, in Proceedings of the European Conference on Computer Vision, Prague, Czech Republic 2004.

41. D. Cremers, N. Sochen and C. Schnoerr, “Multiphase Dynamic Labeling for Variational Recognition-Based Segmentation”, in Proceedings of the European Conference on Computer Vision, Prague, Czech Republic 2004.
42. L. Bar, N. Sochen and N. Kiryati , “Image Deblurring in the Presence of Salt-and-Pepper Noise", in Proceedings of the International Conference on Scale-Space and PDE methods in Computer Vision, Hofgeismar, Germany, April 2005.

Ayellet Tal

Recent Research Interests:

Dr. Tal's research interests are in the areas of computer graphics, scientific visualization, computational geometry, and in particular -their uses in multimedia applications.

Tal's group has been developing new methodologies and has built new tools to help users operate in multimedia environments. During the last couple of years the following topics have been investigated:

- Searching, classifying and reasoning with three-dimensional data in complex 3D environments.
- Surface segmentation.
- Augmented reality where images and three-dimensional models are used together.
- Collision detection, in particular in virtual reality environments.
- Software visualization and graph drawing.

Graduate Students:
The following students have been involved in the above projects:

- Yaniv Frishman – Software visualization and graph drawing
- Sagi Katz – Surface segmentation
- George Leifman – Searching, classifying and reasoning
- Idan Shatz –Augmented reality
- Doron Tal – Augmented reality
- Oren Tropp – Collision detection

Journal Papers:

Hereafter we list the publications since 2000:

1. S. Ar, B. Chazelle and A. Tal."Self-Customized BSP Trees: A Case-Study", *Computational Geometry: Theory and Applications*, 15(1-3):91–102, February 2000.
2. G. Barequet, D. Shapiro and A. Tal. "Multi-Level Sensitive Reconstruction of Polyhedral Surfaces from Parallel Slices," *The Visual Computer*, 16(2):116–133, March 2000.
3. M. Shneerson and A. Tal. "Interactive Collaborative Visualization Environment for Geometric Computing," *Journal of Visual Languages Computing*, 6(6):615–637, 2000.
4. T. Surazhsky, V. Surazhsky, G. Barequet and A. Tal. "Smooth Blending of Polygonal Slices with Different Topologies", *Computers & Graphics*, 25 (1):29–39, 2001.
5. S. Shlafman, A. Tal and S. Katz. "Metamorphosis of Polyhedral Surfaces using Decomposition", *Graphics Forum*, September 2002.
6. S. Ar, G. Montag, A. Tal. "Deferred, Self-Organizing BSP Trees", *Graphics Forum*, September 2002.

7. G. Moiza, A. Tal, I. Shimshoni, D. Barnett and Y. Moses “Image-Based Animation of Facial Expressions”. *The Visual Computer*, 18(7):445–467, 2002.
8. E. Zuckerberger, A. Tal, and S. Shlafman. “Polyhedral Surface Decomposition with Applications”, *Computers Graphics*, (Invited) 26(5):733–743, 2002.
9. G. Leifman, S. Katz, A. Tal and R. Meir. “Signatures of 3D Models for Retrieval”. The 4th Israel-Korea Bi-National Conference on Geometric Modeling and Computer Graphics, February 2003, 159–163.
10. D. Cohen-Or, S. Lev-Yehudi, A. Karol and A. Tal. “Inner-Cover of Non-Convex Shapes”. The 4th Israel-Korea Bi-National Conference on Geometric Modeling and Computer Graphics, February 2003, 17–22.
11. S. Katz and A. Tal. “Hierarchical Mesh Decomposition using Fuzzy Clustering and Cuts”, SIGGRAPH ’2003 (ACM Transactions on Graphics), Volume 22 , Issue 3, July 2003, 954-961.
12. D. Cohen-Or, S. Lev-Yehudi, A. Karol and A. Tal. “Inner-Cover of Non-Convex Shapes”. International Journal of Shape Modeling, 9:2, 2003, 223–238.
13. Y. Moses, Z. Polunsky, A. Tal and L. Ulitsky, “Algorithm Visualization for Distributed Environments”. Journal of Visual Languages and Computing, Volume 14, January 2004, 97–123.
14. B. Chazelle, J. Kilian, R. Rubinfeld and A. Tal. “The Bloomier Filter: An Efficient Data Structure for Static Support Lookup Tables”, ACM-SIAM Symposium on Discrete Algorithms (SODA) 04, January 2004, 30–39.
15. T. Funkhouser, M. Kazhdan, P. Shilane, P. Min, W. Kiefer, A. Tal, S. Rusinkiewicz, D. Dobkin. “Modeling by Example”, SIGGRAPH 2004 (ACM Transactions on Graphics), Vol 23, No 3, August 2004, 652–663.
16. S. Keren, I. Shimshoni and A Tal, “Placing Three-Dimensional Models in an Uncalibrated Single Image of an Architectural Scene”, PRESENCE, Vol 13, No 6, December 2004, to appear (invited to a special issue).
17. Y. Frishman and A. Tal. “Dynamic Drawing of Clustered Graphs”, IEEE Symposium on Information Visualization, October 2004, 191–198.
18. G. Leifman, R. Meir and A. Tal. “Relevance Feedback and 3D Shape Retrieval”, The 5th Israel-Korea Bi-National Conference on Geometric Modeling and Computer Graphics, October 2004, 15-19.
19. O. Hazzan, D. Levy and A Tal. “Electricity in the Palms of Her Hands -The Perception of Electrical Engineering by Outstanding Female High School Pupils”, IEEE Transactions on Education, accepted.

Conferences:

1. S. Shlafman, A. Tal and S. Katz, "Metamorphosis of Polyhedral Surfaces using Decomposition", *Eurographics '02*, September 2002.
2. S. Ar, G. Montag, A. Tal, "Deferred, Self-Organizing BSP Trees", *Eurographics '02*, September 2002.
3. Koifman, I. Shimshoni and A Tal, "MAVIS: A Multi-Level Algorithm Visualization System within a Collaborative Distance Learning Environment", *IEEE Symposium on Human Centric Computing Languages and Environments '02,* September 2002.
4. S. Keren, I. Shimshoni and A Tal, "Placing Three-Dimensional Models in an Uncalibrated Single Image of an Architectural Scene", ACM *Symposium on Virtual Reality '02*, 186-193, 223 November 2002.
5. G. Leifman, S. Katz, A. Tal and R. Meir, "Signatures of 3D Models for Retrieval", *The 4th Israel-Korea Bi-National Conference on Geometric Modeling and Computer Graphics*, February 2003, 159–163.
6. D. Cohen-Or, S. Lev-Yehudi, A. Karol and A. Tal, "Inner-Cover of Non-Convex Shapes", *The 4th Israel-Korea Bi-National Conference on Geometric Modeling and Computer Graphics*, February 2003, 17–22.
7. S. Katz and A. Tal, "Hierarchical Mesh Decomposition using Fuzzy Clustering and Cuts", *SIGGRAPH '2003*, July 2003.
8. B. Chazelle, J. Kilian, R. Rubinfeld and A. Tal, "The Bloomier Filter: An Effcient Data Structure for Static Support Lookup Tables", *ACMSIAM Symposium on Discrete Algorithms (SODA) 04*, January 2004.
9. T. Funkhouser, M. Kazhdan, P. Shilane, P. Min, W. Kiefer, A. Tal, S. Rusinkiewi cz, D. Dobkin, "Modeling by Example", *SIGGRAPH '2004*, August 2004.
10. Y. Frishman and A. Tal, "Dynamic Drawing of Clustered Graphs", *IEEE Symposium on Information Visualization*, October 2004.

Michael Zibulevsky

Recent Research Interests:

- Nonlinear Optimization
- Neural Networks, Tomography
- Independent Component Analysis
- Sparse Representations of Signals and Images

Graduate Students:

Ph.D. Students:

* Pavel Kisilev (jointly with Y.Y. Zeevi), Multiresolution methods in blind source separation and other inverse problems (finished in 2003).
* Michael Lisyansky (jointly with D. Adam), Solution of the inverse problem in ultrasound imaging (passed the exam of Ph.D. candidate.)

M.Sc. Students:

* Haggit Sandhaus (jointly with H. Pratt and R. Meir), Locating activity regions in brain using methods of source separation (finished in 2003).
* Stas Cherkassky, Listmode 3D reconstruction in positron emission tomography using Bundle-Mirror optimization algorithm (finished in 2004).
* Alexander Bronstein (jointly with Y.Y. Zeevi), Quasi-ML blind deconvolution: optimization methods and stability (thesis submitted).
* Michael Bronstein (jointly with Y.Y. Zeevi), Optimization methods for sparse blind source separation.
* Alexsey Polonsky, Source localization in magnetoencephalography using sparse representations (thesis submitted).
* Dmitry Model, Multisensor signal reconstruction using spatio-temporal sparsity.
* Sarit Schvartz (jointly with Y. Schechner), Blind sepatation/deconvolutoin of optical images.
* Guy Narkiss (jointly with B.A. Pearlmutter), Neural Spike Sorting using ICA.
* Boaz Matalon (joint with M. Elad). Sparse overcomplete representations of images.

Book Chapters:

2. Zibulevsky, M., Pearlmutter B.A., Bofill P. (2001). Blind Source Separation by Sparse Decomposition, in Roberts, S.J & Everson R.M. (Eds.), Independent Components Analysis: Principles and Practice}, Cambridge University Press, pp. 181-208.

Journal Papers:

Published (and Accepted) Articles:

16. Shwartz S., Zibulevsky M., and Schechner Y.Y. (2004), Kernel entropy estimation and optimization with NlogN complexity, Signal Processing, accepted.
17. Bronstein A., Bronstein M. and Zibulevsky M. (2004). Relative optimization for blind deconvolution, IEEE Trans. on Signal Processing, accepted.
18. Bronstein A., Bronstein M., Zibulevsky M. and Zeevi Y.Y. (2004). Quasi-ML blind deconvolution of images using optimal sparse representations, IEEE Trans. on Image Processing, accepted.
19. Bronstein A., Bronstein M. and Zibulevsky M. (2004). Block-coordinate relative Newton method for blind source separation, Signal Processing, accepted.
20. Kisilev P., Zibulevsky M. and Zeevi Y.Y. (2003). Multiscale blind source separation, Journal of Machine Learning Research, accepted.
21. Bronstein A., Bronstein M., Zibulevsky M. and Zeevi Y.Y. (2003). Optimal nonlinear estimation of photon coordinates in PET, IEEE Transactions on Nuclear Science, vol.50, No 3, pp. 421-427.
22. Bronstein M., Bronstein A., Zibulevsky M. and Azhari H. (2002). Iterative reconstruction in diffraction tomography using non-uniform FFT, IEEE Transactions on Medical Imaging, vol. 21, No 11, pp. 1395-1402.
23. Zibulevsky, M. and Zeevi Y.Y. (2002). Extraction of a Single Source from Multichannel Data Using Sparse Decomposition, Neurocomputing, 49, pp 163-173.
24. Bofill P., Zibulevsky, M. (2001). Underdetermined Blind Source Separation using Sparse Representations, Signal Processing, Vol.81, No 11, pp.2353-2362.
25. Zibulevsky, M. and Pearlmutter, B.A. (2001). Blind Source Separation by Sparse Decomposition in a Signal Dictionary, Neural Computations, vol.13, No 4, pp.863-882.
26. Levkovitz R., Falikman D., Zibulevsky M., Ben-Tal A., Nemirovski A. (2001). The design and implementation of COSEM, an iterative algorithm for fully 3D listmode data, IEEE Trans. Med. Imaging, v.20, No 7
27. Mosheyev, L. and Zibulevsky, M. (2000). Penalty/Barrier Multiplier Algorithm for Semidefinite Programming, Optimization Methods and Software}, vol.13, No 4, pp. 235-261.
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29. Kochvara, M., Zibulevsky, M. and Zowe, J. (1998). Mechanical Design Problems with Unilateral Contact, MAN – Mathematical Modeling and Numerical Analysis, v.32, no 3, pp. 255-282
30. Ben-Tal, A. and Zibulevsky, M. (1997). Penalty/Barrier Multiplier Methods for Convex Programming Problems, SIAM Journal on Optimization v. 7 # 2, pp. 347-366.

Conferences:

1. Bronstein A., Bronstein M., Zibulevsky M. and Zeevi Y.Y., "Optimal nonlinear estimation of photon coordinates in PET," *Proceedings of IEEE International Symposium on Biomedical Imaging*, Washington, D.C., 2002.
2. Bronstein M., Bronstein A. and Zibulevsky M., "Iterative reconstruction in diffraction tomography using non-uniform FFT," *Proceedings of IEEE International Symposium on Biomedical Imaging*, Washington, D.C., 2002.
3. Zibulevsky M., "Relative Newton method for Quasi-ML blind source separation", *International Workshop on Independent Component Analysis and Blind Signal Separation*, Nara, Japan, 2003.
4. Kisilev P., Zibulevsky M. and Zeevi Y.Y., "Blind Separation of Mixed Images in Subspaces of Sparse Representations", *Wavelet X Conference*, San Diego, CA, 2003.
5. Zibulevsky M., "Sparse source separation with relative Newton method", (invited paper) *Wavelet X Conference*, San Diego, CA, 2003.
6. Bronstein A., Bronstein M., Zibulevsky M. and Zeevi Y.Y., "Separation of semireflective layers using Sparse ICA", *ICASSP 2003*, Hong Kong
7. Zibulevsky M., "Relative Newton method for sparse source separation", *ICASSP 2003*, Hong Kong.
8. Polonsky A. and Zibulevsky M., "MEG/EEG Source Localization Using Spatio-Temporal Sparse Representations", *International Workshop on Independent Component Analysis and Blind Signal Separation*, Granada, Spain, 2004.
9. Model D. and Zibulevsky M., "Signal reconstruction in sensor arrays using temporal-spatial sparsity", *International Workshop on Independent Component Analysis and Blind Signal Separation*, Granada, Spain, 2004.
10. Shwartz S., Zibulevsky M., and Schechner Y.Y., "ICA using kernel entropy estimation with NlogN complexity", *International Workshop on Independent Component Analysis and Blind Signal Separation*, Granada, Spain, 2004.

4. Scientific Output and Impact of the Ollendorff Center

Research conducted at the Ollendorff Center has contributed to several areas of scientific and technological frontiers. Scientists of the Ollendorff center were among the first to identify the importance of representaions in combined spaces in the context of vision (both biological and computional or machine vision) and image processing. This work is widely cited and, in a way, has affected the development of the wavelets formalism, at least insofar as representaions of two-dimensional signals, i.e. images, are concerned. This research was extended to incorporate multiwindow Gabor Frames, the impact of which is constantly gaining momentum. Dr. Porat has made a seminal contribution to the understanding of of the importance of localizes (i.e. Gaborian) phase, by establishing the conditions for optimal reconstruction from partial information. More recently the Gaborian representations have been incorporated into the variatinal approach and, by Sochen, into the Beltrami framework, in dealing with fully textured images. This is the subject of the thesis of Chen Sagiv (see publications), jointly supervised by Sochen and Zeevi.

The contributions of Ollendorff's scientists to representations include also a generalized approach to wavelets, using a group theoretic approach. This approach considers the classical case of wavelets as a special case of a basis or a frame, suitable for the representaion of subspace of images, obtained by the action of a group on a generating function, known in the context of wavelets as mother wavelet. The contributions of the Ollendorff Center to image representations has been further extended in recent years by Dr. Zibulevsky who was among the first to highlight the importance of sparse representatins in the solution of ill-posed problems such as blind source separation and blind deconvolution. The simple but important observation that sparse representations of mixed images projected onto the scatter plots identify the columns of the mixing matrix lends itself to a powerful geometrical approach to blind source separation. The group comprised of Zeevi, Zibulevsky and the Bronstein brother have exploited this approch in the solution of various practical engineering problems such as separation of reflections superimposed on an image acquired through a semi-reflective medium. This approach has been further extended by Zeevi and students to the dynamic case (see, for example, the separation of clouds from and image demonstrated on the website of the VISL). This research has been incorporated into the European Network Program comprised of research conducted in seven universities in GB, Germany, France, Belgium and Israel. This program aims at exchange of scientists, sharing know-how and exchange of graduate students among the participating universities (see website of the HASSIP program - http://www.cmi.univ-mrs.fr/HASSIP/).

The research on the topics of BSS and blind deconvolution benefited also from the expertise of Dr. Zibulevsky in optimization. The algorithms of optimization by relative Neuton combined with sparse representations yields very powerful approch to problems of BSS and blind deconvolution, and has already considerable impact on this field. One facet of this research that has already been presented in conferences has the potential to have considerable impact on medical images. Zeevi has made the observation that MRI images can be considered to be linear mixtures of signatures

of tissue components. Thus, obtaining a set of two or more images under different set of physical parameters of the magnetic field, RF and/or contrast agents, yield several different mixtures that can be separated by the BSS approach to yield in turn the distribution of tissue signatures. The same approach has been applied to medical images obtained in cavities by multispectral imaging systems. This research is conducted in collaboration with scientists and medical doctors at Columbia Unversity and NYU, and their teaching hospitals. In these and other examples the assumption of indepedence is not necessarily valid. Consequently, the ICA approach is not effective. However, using the prior of sparsity in the context of sparse component analysis (SCA) does not necessitate the assumption of imdependense. In fact, sparsity is a much more powerful assumption also in cases where the ICA approach is valid.

Although Dr. Schechner and Dr. Eldar are among the newcomers who joined the Ollendorff Center only a few years ago, the research conducted by them has had already considerable impact and they have been awarded with very prestigious prizes and fellowships. Dr. Schechner's recent research on computer vision under water integrates the understanding of the imaging medium into the computational algorithm applied to the cloudy image. The novelty of his approach is in getting the added value of depth information in the process of recovery of underwater visibility and structure by polarization analysis.

Dr. Eldar is very prolific in various fields that extend beyond the activities of the Ollendorff Center. However, her expertise in sampling methods and frame theory are within the scope of issues central to the Ollendorff center, e.g. Gabor representations. Dr. Eldar has introduced a new approach to signal processing: The so-called quantum signal processing. Her approach was the enter piece of the Signal Processing Magazine, and has had a considerable impact on the thinking of the signal and image processing community.

Prof. Meir's contributos to the field of pattern classification and recognition are gaining momentum. Prof. Meir's approach to such problems incorporates the development and analysis of advanced learning algorithms for pattern classification and recogniton, for which he is well known and often invited to conferences and workshops (see, for example his paper on "Greedy Algorithms for Classification, J. Machine Learning, 2003).

Dr. A. Tal brings into the center her expertise in computer graphics and computational geometry. In particular, she is known for her work on three-dimensionl models and shape retrieval with applications to multimedia environments, for which she has introduced new methodologies. Her work on modeling and retrieval of 3D data has a tremendeous potential in medical imaging and procedure planning.

5. Cooperation

The Ollendorff Center has established several effective modes of cooperation with research centers and individual scientists in Germany. These include the program of German-Israeli Bi-National Ollendorff Workshops and Symposia, exchange of scientist and graduate students, and participation in European Networks of Excellence, sponsored by the European Commission.

The highlight of interaction with German colleagues, that has evolved to become a bi-national network in vision and image sciences, is the Program of Ollendorff Workshops. Four such workshops took place in the last seven years; three in Israel and one in Germany. It should be stressed that the last workshop was well attended in spite of the atmosphere in Israel that continues to affect the reservations and concerns of our colleagues and students from abroad about making trips to Israel. It appears that these conditions have started to change for the better, and we hope that soon our interactions and exchange of scientists and students will flourish again.

Workshops

1998 – The Ollendorff Minerva Center co-sponsored with the Leibniz Institute of the Hebrew University a Workshop on Image Understanding and Computer Vision. This was jointly organized by Prof. S. Peleg of the Hebrew University, Prof. H.-H. Nagel of the Fraunhofer Gesellschaft and Y.Y. Zeevi.

March 2002 – The Ollendorff German-Israeli Symposium on Image Processing and Computer Vision took place at the Technion, with the participation of ten leading German scientists, including Prof. Hans Burkhart, Prof. Joachim Buhmann, Prof. Christoph Schnoerr of the University of Mannheim, Prof. Gerhard Sommer, of Kiel University, who like Professors Schnoerr, Burkhart and Buhmann visited the Ollendorff Center more than once and became members of the wider family of the center. Other participants in this symposium were Prof. U. Rueckert, Prof. G. Sagerer, Prof. T. Vetter, Prof. G. Hauske, Prof. R. Klette and Prof. R. Mester.

October 2002 – The Vision and Image Science Workshop at Schloss Dagstuhl in Wadern. Again the Israeli delegation was co-sponsored by the Libniz and Ollendorff Minerva Centers. The Israeli delegation included faculty members and graduate students from both the Hebrew University and the Technion, and representatives of both centers were members of the organizing committee, in addition to Prof. Helge Ritter and Prof. Christoph Schnoerr. The Dagstuhl Workshop dealt with fundamental issues that are essential for extraction of meaning from images: 1. Creation of lower dimensional representations of originally much higher dimensional image data – an issue of long interest and concerted effort of the Ollendorff Center, 2. Partition of images into meaningful constituents that correspond objects or actions, a topic that is dealt with also later in the

subsequent Ollendorff Workshop and is of great interest in centers in Germany and the Ollendorff Center, 3. The application of neural networks in vision processing, a topic that has been recently further expanded at the Ollendorff Center by Professor Ron Meir, and 4. The application of geometric and Algebraic mathematical concepts in vision – a topic pioneered by Prof. Gerald Sommer in Keil and by Dr. Nir Sochen of Tel-Aviv University and the Ollendorff Center.

October 2004 – The Ollendorff Workshop took place again at the Technion, with the participation of an impressive delegation of eleven German scientists, including three graduate students. As most of the regular German counterparts of the Ollendorff Center were unable to participate in this workshop because of teaching and administrative responsibilities in their home universities, it was decided to structure the workshop around core of topics of interest of two research groups in Germany that have already established some earlier contacts with Ollendorff Center's scientists and where there is a strong affinity to the Ollendorff Center. These are the groups of Prof. Klaus-Robert Mueller of the Fraunhofer Institute FIRST in Berlin, and the group of Prof. Joachim Weickert of Saarland University. Accordingly, an organizing committee was established, including Prof. Mueller, Prof. Weickert and Y.Y. Zeevi. In addition to scientists from these two institutes, three graduate students from these two groups participated and gave presentations, as did graduate students of the Ollendorff Center.

Exchange of Scientists

The Ollendorff Center has sponsored visits of scientists and graduate students to German institutes for the purpose of giving presentations and developing joint programs during the seven years of this report the center sponsored 32 such visits to Germany and from Germany to the Technion. In 2004 it sponsored six such visits including the visit of Dr. Guy Gilboa, a former graduate student of Sochen and Zeevi, to Saarland as part of the joint effort to develop closer interactions among the two groups. It is expected that Dr. Martin Welk of Weickert's group, who participated in the 2004 Ollendorff Workshop and expressed interest in the research on blind deconvolution that is carried out at the Ollendorf Center will come for an extended visit to the Technion. Exchange of graduate students between these two groups is being explored. The visit of Dr. Y. Eldar of the Ollendorff Center to Düsseldorf University for the purpose of developing a joint research program has already resulted in a visit of one of their scientists who spends now a month at the Technion.

Dr. Schechner of the Ollendorff Center visited Prof. Gerald Sommer and Reinhard Koch of Kiel. Dr. Schechner's trip to Germany was sponsored by a special grant awarded to him under the Program of "Young Scientists". Dr. Schechner also visited Dr. Joerge Polzhel of the Weirstrass Institute, Berlin, and it is very likely that a joint research program will soon be developed.

Joint Participation in European Research Programs

Other interactions of Ollendorff Center's scientists with German counterparts are carried out via projects sponsored by the European Community, e.g. the Hassip program in which several members of the Ollendorff Center, including Prof. Zeevi, Dr. Zibulevski, Dr. Eldar and Dr. Porat, participate (see HASSIP website - http://www.cmi.univ-mrs.fr/HASSIP/).

Ron Meir of the Ollendorff Center participates in the Networks of Excellence, another European Program.

6. Future Activities and Research Plan

Now that Professor Allen Tannenbaum rejoined the Technion, he is becoming one of the leading senior scientists of the center. Having Professor Tannenbaum in the center will strengthen the capabilities in theory and practical research in the area of medical image processing and computer vision approach to medical problems. Thus, medical imaging will become in the coming years one of the central themes of research activities of the Ollendorff Center. The geometrical approaches to image processing and computer vision, introduced at the Center by Dr. Nir Sochen will gain momentum, since this is one of the strengths of Prof. Tannenbaum for which he is well known.

Sparse representations in the context of blind source separation and blind deconvolution will continue to be central to the research conducted at the center, with special emphasis on the application of these formalisms and algorithms to the analysis of medcial images such as those obtined by MRI, but also to other modalities. Multispectral approches in the context of BSS and SCA, developed independently by Schechner and Zeevi will also be applied to medical images and medical imaging, as well as to other problems of imaging in scattering media. One specific application of tremendous importance is imaging in the blood. This is in particular suitable for a group effort at the Ollendorff Center, thanks to te combination of experts in optical electronics and electro-optics (Horowitz and Fischer), BSS algorithms and blind deconvolution (Zeevi, Zibulevsky and Schechner) and geometrical approaches to extured images (Tannenbaum, Sochen and Zeevi). The center will continue to explore possible modes of collaboration with the group of Prof. Mueller of the Fraunhofer Institute in Berlin, as well as with the University Hospital in Hamburg and other centers.

The geometrical and PDE approach to image segmentation and enhancement is another area that the Ollendorff Center will continue to be active in. In this area the Ollendorff center has already established excellent relations with Prof. Weickert's group in Saarland. This will also incorporate interactions with the group of Prof. Peter Maass of the University of Bremen. Prof. Mass and Prof. Zeevi have been interacting within the context of the HASSIP Program. With the return of Dr. Gilboa (a former student of Sochen and Zeevi) to the Technion for his second year of

postdoctoral position with Tannebaum and Zeevi, he will serve as a liaison between the Saarland group and the Ollendorff Center.

A third major activity will be devoted in the coming years to new computational approaches and architectures based on, and motivated by, experimental data and algorithms deciphered from the processing of cortical tissue in vitro. The leading figure in this effort, which has already begun this research program, is Prof. Meir, with the complementary research conducted by Zeevi and his students on processing and storage by synfires and cliques.

Professor Tannebaum has been working also on engineering and computer science approch to the analysis of RNA and other molecules. The recent effort of Zeevi and his student on the application of multiwindow and other combined space approaches to labeling and indexing of macromolecules will be combinded into a central topic to be jointly conducted at the center. It is too early to select the proper partners in Germany. However, we are aware of the fact that these topics ore of great interst to several leading scientists in Germany.

Problems of generalized sampling have been approached by Dr. Porat and Dr. Eldar independently. Based on some recent results it seems that Ollendorff Center's scientists have identified open issues related to the classical work on sampling. In particular, the recent research of Porat and his students on the effect of sampling on algebric relations appear to be very promising. In view of our general interest in uniform and nonuniform exact and undersampling problems, in the context of conventional and unconventional representations, and in view of the existence of some outstanding issues in the context of nonuniform sampling of images, this may develop into another major topic that has the potential to have considerable impact. It should be mentioned in this context that nonuniform sampling has been addressed by Ollendorff's systems (see Zeevi's papers on reproducing kernels) and in the context of image representation by zero crossings.

A detailed research plan will be provided in the coming months, after Prof. Tannebaum will settle in Israel.

7. Workshops

THE OLLENDORFF GERMAN-ISRAELI SYMPOSIUM on Image Processing and Computer Vision

Electrical Engineering Department
Room 815 (8th floor), Andre Meyer Building
Technion-Israel Institute of Technology
Haifa, Israel

March 7–9, 2000

Tuesday March 7, 2000

10:00	*Welcome Greetings* Maj. Gen. (Res.) Amos Lapidot, President Professor Avraham Shitzer, Vice Provost for Research Professor Yehoshua Zeevi, Head, Ollendorff Minerva Center Professor Hans Burkhardt, Ollendorff Workshop Committee
10:30–12:45	First Technical Session: Chairperson: Shmuel Peleg, Hebrew University of Jerusalem
10:30–11:00	Prof. Dr. Joachim M. Buhmann, University of Bonn Robust Multi-Scale Image Segmentation by Maximum Entropy Methods
11:00–11:30	Dr. Yitzhak Birk, Technion, and the Ollendorff Center On the Multiple Dimensions of Performance and Implications to System Architectures
11:30–11:45	*Coffee Break*
11:45–12:15	Prof. Dr. Hans Burkhardt, Albert-Ludwigs-University Invariants for Pattern Recognition
12:15–12:45	Prof. Shmuel Peleg, Hebrew University of Jerusalem Panoramic Imaging in Stereo
13:00–14:30	*Lunch Break*
14:30–16:00	Second Technical Session: Chairperson: Dan Adam, Technion.
14:30–15:00	Prof. Dr. rer.nat. Georg Hartmann, Universität-GH Paderborn Object Recognition by Hybrid Neuro - AI - Systems
15:00–15:30	Dr. Renato Keshet (Kresch), Hewlett-Packard Laboratories Haifa A Morphological View on Image Pyramids
15:30–16:00	Prof. Dr.-Ing. Gert Hauske, Munich University of Technology: Nonlinear Information Processing: Detection of Points, Corners, and Curvature. Biological and Technical Alternatives to Redundancy Reduction
16:00–16:15	*Coffee Break*
16:15–18:15	Third Technical Session: Chairperson: Hans Burkhardt, Albert-Ludwigs-University
16:15–16:45	Dr. Nahum Kiryati, Tel-Aviv University Towards Segmentation from Multiple Cues: Symmetry and Color
16:45–17:15	Prof. Dr. Reinhard Klette, Auckland University/University of Kiel Multigrid Convergence and Image Analysis
17:15–17:45	Dr. Ron Meir, Technion, and the Ollendorff Center Localized Approaches to Boosting
17:45–18:15	Prof. Alfred M. Bruckstein, Technion Fiducials for Self-Location
18:30	*Reception at the Coler-California Visitors Center*

09:30–12:15	First Technical Session: Chairperson: Yehoshua Zeevi, Technion, and the Ollendorff Center
09:30–10:00	Prof. Dr. Rudolf Mester, J.W.Goethe-Universitaet Frankfurt Statistical Methods in Image Processing and Computer Vision
10:00–10:30	Dr. Ayellet Tal, Technion, and the Ollendorff Center Metamorphosis by Compatible Triangulation
10:30–10:45	*Coffee Break*
10:45–11:15	Prof. Dr.-Ing. Ulrich Rueckert, Universität-GH-Paderborn The Silicon Way to Artificial Neural Networks
11:15–11:45	Dr. Moshe Porat, Technion, and the Ollendorff Center Localized Processing in Vision and Image Computing
11:45–12:15	Prof. Dr. Gerhard Sagerer, Universitat Bielefeld Structurm and Process: A Vision System for Learning and Supervising the Construction of Complex Objects
13:00–14:30	*Lunch Break*
14:00–16:30	Second Technical Session: Chairperson: Georg Hartmann, Universität-GH Paderborn
14:00–14:30	Hector Rotstein, Rafael, and the Ollendorff Center A Multi-Camera Active Vision System
14:30–15:00	Prof. Dr. Christoph Schnoerr, University of Mannheim On Bottom-Up, Model-Based, and Recognition-Based Image Segmentation
15:30–16:00	Dr. Doron Shaked, Hewlett-Packard Laboratories Haifa Color Halftoning
16:00–16:30	Prof. Dr. Gerald Sommer and Sven Buchholz, University of Kiel Hyperbolic Perceptron as Classifier
16:30–16:45	*Coffee Break*
16:45–18:15	Third Technical Session: Chairperson: Gerald Sommer, University of Kiel
16:45–17:15	Dr. Nir Sochen, Tel-Aviv University, and the Ollendorff Center Enhancement of Non-Euclidean Feature Spaces
17:15–17:45	Prof. Dr. Thomas Vetter, Universitat Freiburg Learning the Appearance of Faces: A Morphable Model for the Analysis and Synthesis of Images
17:45–18:15	Prof. Yehoshua Zeevi, Technion, and the Ollendorff Center Biologically-Motivated Approaches to Image Processing in Vision Systems
20:30	*Dinner Meeting at the Dan Carmel (Rimon Hall)*

Thursday March 9, 2000

09:00–	*Excursion*
20:00	*Dinner at the Nof Hotel*

Workshop at Schloß Dagstuhl:

Vision and Image Science

Helge Ritter*, Christoph Schnörr+,

Shmuel Peleg†, Joshua Zeevi#

*Faculty of Technology, Bielefeld University
+Computer Science Dept., University of Mannheim
†Leibniz Minerva Center, Hebrew University, Jerusalem
#Ollendorff Minerva Center, Technion Israel Institute of Technology, Haifa

1 Motivation of the Subject

Human vision can instantly and effortlessly extract rich meaning from a million of colored dots composing a natural image. To understand this capability and to simulate it in a computer continues to be one of the grand scientific challenges of our time.

At the same time, the rapid development of modern storage technology in conjunction with the now wide-spread availability of cheap digital image acquisition devices and world wide high-bandwidth networking facilities has transformed the way we acquire, store and exchange information. We witness the growth of huge image databases in many application fields and a corresponding need for content based retrieval techniques that are directly based on the image data itself instead of keyword indexing.

As a result, there is now a large number of application areas for which Vision and Image science is of immediate and vital importance: besides the more „traditional" fields such as machine and robot vision for vehicle guidance or industrial automation there are many new application areas that are faced with diagnosis tasks that are centrally based on image data. Examples include medical image analysis, satellite surveillance, data mining, industrial quality control and many others. Finally, an increasing number of applications are intimately connected with the need to use, maintain and search large image data bases, such as the press and film media business, as well as databases for science and education.

This broad applicability, together with the advent of increasingly powerful and yet affordable computing resources that are beginning to narrow the gulf between the processing capabilities of biological and artificial vision systems has transformed the field of vision and image science into a topic which is in rapid and exciting development. The highly interdisciplinary nature of many questions, ranging from computer science and often deeply into neighboring disciplines, such

as mathematics, biology, engineering, physics, cognitive science and others, this has made it difficult for students and young researchers to track the rapidly moving research frontier. Therefore, it is the goal of the proposed workshop to bring together a number of leading scientists to discuss major recent developments and offer young researches the opportunity to exchange ideas and assimilate an up-to-date picture of the current state of the art.

The intended audience is comprised of graduate students and junior researchers specializing in an area in which information extraction from images constitutes a major topic. In computer science and engineering, this is an important issue in a large number of fields, including computer and robot vision, human-machine-interaction, neuroinformatics, databases, machine-learning, information theory, pattern recognition and artificial intelligence. However, the topic is also of great importance for students from many neighboring disciplines, in particular biology (computational neuroscience, biology of vision), mathematics and physics (neural networks, dynamical systems theory), cognitive science (visual perception, gestalt laws, similarity judgements) as well as others.

The workshop will focus on a number of key questions that must be answered in order to extract meaning from images. Specifically, we want to discuss methods

(i) to create lower-dimensional representations of the originally extremely high-dimensional image data and their use for measuring image similarity in ways that are compatible with human judgements,

(ii) to partition images and image sequences into meaningful constituents that correspond to objects or actions in order to obtain a basis for a more compact representation at a semantic level,

(iii) to use artificial neural networks to perform important steps in vision processing, such as classification and perceptual grouping

(iv) to integrate information from multiple views of the same scene,

(v) to apply advanced geometric and algebraic mathematical concepts in these contexts.

Furthermore, since it will be difficult to entirely rely on handcrafted solutions for the above questions an overarching and important issue is the

(vi) development of learning approaches that allow to synthesise solutions for (i) – (v) in a data-driven and preferably unsupervised way from large collections of training images or from accumulating relevance feedback during the use of a database.

2 Course Topics

2.1 Image Similarity and Metric Embeddings

(Burkhardt, Schnörr, Weinshall)

A fundamental problem of vision and image science concerns adequate representations of high-dimensional visual data for processing, classification and recognition. According to the hierarchy of processing levels ranging from low- to high-level vision, researchers are confronted with diverse representations such as function spaces for image signals, combinatorial structures like partition lattices or graphs representing object views, or tree-like hierarchical organizations of visual object classes.

Closely related with a particular representation is the induced similarity measure. Recent research on image retrival from large data bases revealed the importance of similarity measures compatible with human vision which appears to violate properties of the usual mathematical definition of a metric. This may have dramatic consequences for the definition of operations on distance spaces. Properties of similarity measures are also important for the ranking a set of images according to a given collection of ranking or preference functions. Here, an interesting issue closely connected with 2.4 are efficient learning algorithms for combining preference measures, e.g., through boosting.

The workshop will focus on *metric embeddings* and *image similarity* as central themes of visual information processing, in order to shed light on hidden interrelations between different branches of current research in vision and image science.

2.2 Image Partitioning

(Peleg, Schnörr)

Partitioning of data sets is another key functionality of visual data processing which shows up under the notions segmentation, grouping, classification, or clustering.

One important approach is based on stochastic mixture models for identifying significant components of an image. Here, a basic and very important case is the partitioning of an image into line-segments. We will present recent results on PAC algorithms for efficiently and accurately discovering line segments as well as more general geometric objects on the basis of such models.

Additionally, we will consider the task of partitioning from the viewpoint of constructing and optimizing metric embeddings for recognizing the "true" struc-

ture of given data. Here, we will stress the optimization viewpoint and focus on the important question of how additional degrees of freedom can be introduced in order to relax the combinatorial problem of data partitioning and to compute high-quality solutions in polynomial time.

2.3 Neural Approaches to Computer Vision

(Heidemann, Meir, Pauli, Zeevi)

Neural networks have been very successfully applied to many aspects of computer vision. One major and important area are neural learning approaches for fast classification and for the identification of continuous degrees of freedom, as they occur for articulated or deformable objects. Here, it has become apparent that methods that combine local models can lead to powerful approaches for extracting visual knowledge from data. We will present several such approaches and also discuss their relationships with metric embeddings and image similarity measures considered in 2.1.

A second important domain are recurrent networks. Their capabilities go beyond non-linear mappings in that they possess rich possibilities for complex dynamics which can be used, e.g., to solve tasks like perceptual grouping of image features. While general recurrent networks are very hard to analyse, more specialized architectures can be shown to converge to desired attractors. We will present a recent model, discuss its properties and connections with the methods in 2.2 and point out extensions aiming at learning perceptual grouping capabilities from data examples.

Adaptive retina-type nonlinear networks with feedback (i.e. recurrent networks) will be discussed as examples of architectures that accomplish spatio-temporal automatic gain control. Such networks exhibit a wide dynamic range with high sensititvity.

2.4 Learning Approaches

(Buhmann, Meir, Ritter, Tishby)

Machine learning approaches have in recent years gained wide applicability in many fields such as Pattern Recognition and Computer Vision, to name but a few. Besides specific learning approaches already discussed in the sections above we will discuss general concepts how to combine the results of several "weak" learning modules in order to obtain high-precision classifiers. We focus particularly on the technique of *boosting*, which is considered to be among the most important recent

contributions to both the theory and the practice of machine learning and Pattern Recognition.

The boosting approach is particularly appealing in computer vision, where the construction of single high-quality classifiers is often computationally intractable due to the high dimensionality of the input space. We show that under mild geometric conditions on the structure of the input points we may still be able to construct sufficiently accurate linear classifiers by an efficient algorithm. Once such learners exist, one can then apply Boosting to obtain computationally tractable learning under these assumptions. Theoretically derived performance bounds together with a great deal of recent numerical evidence show convincingly that this type of approach provides for some of the best general purpose classifiers available today.

2.5 Multiple Views

(Canterakis, Peleg)

Scenes can be represented from a collection of images covering the scene. One such representation is, for example, a panoramic mosaic, which combines a sequence of images into a one panoramic picture of the entire scenes. In order to create a useful representation, the manifold on which the images are generated should be adaptive to camera motion, and should be deducted automatically from the input images. We will describe several image-based scene representations, including those that can capture the 3D structure of the scene and display stereo images.

Additionally, we consider the issue of learning of the structure of dynamic scenes from multiple images. Here, we present new methods for the learning of structure of dynamic scenes, where objects as well as the camera are allowed to move and show how both the structure of the scene, as well as the motion of the camera and the object, can be learnt from multiple images of the scene taken at different times.

2.6 New Geometric and Algebraic Concepts

(Sochen, Sommer, Zeevi)

Differential geometry and stochastic calculus offer a rich set of tools to reformulate different problems in image processing and vision. These formulations result in a new powerful approach to image processing, analysis and understanding.

One way to improve the representations in vision and image sciences is to focus on the original problem of recognizing geometrical structures and objects,

their changes and mutual relations. With the aid of algebraic embeddings of the task at hand into suitably chosen Clifford algebras we can construct linear representations of higher order and multi-dimensional entities. The resulting framework of geometric algebra uses multivectors as rich representations for image structure and can tremendously facilitate computations for otherwise difficult to handle higher-order entities. We illustrate this approach with examples, such as Clifford neurons and spinor Clifford neurons as linear operators for various geometric transformations.

A second line of approach considers data of a given experimental scenario as differential manifolds. Of particular interest in this regard is the geometric *Beltrami framework* for image processing. This approach is based on geometrical ideas adopted from general relativity and high energy physics and represents the data structure of a two-dimensional image as an embedding map of a Riemannian surface in a spatial-feature fiber bundle. The base manifold is the graph of the image, called the image manifold. Image attributes and features, such as brightness, color, texture orientations and gradients are the fibers.

A one-parameter family of embedded images is introduced, with scale or "time" being the evolution independent variable describing a flow on a two-dimensional surface governed by a nonlinear heat equation. We show how this formalism can be applied to gray-level, color and texture enhancement and how a-priori and empirical/statistical knowledge can be naturally introduced through an appropriate change in the Riemannian structure of the embedding space. Texture is analyzed with the Morlet wavelets. The latter are complex functions of position, scale and orientation. This approach is described as a four-dimensional manifold embedded in a six-dimensional Euclidean space. Based on this representation, new denoising and segmentation algorithms are designed and it is shown that the geometry of the embedding space serves as an interface between low-level vision tasks and higher levels of processing of the visual (or other) information.

Topics for Wednesday Evening Discussion:

Learning low and mid-level vision

Many existing approaches to low level vision involve minimizing energy functions. These energy functions are often proposed based on heuristics and involve arbitrary parameters. Using recent advances in approximation algorithms for statistical inference and learning, can we now rigorously learn algorithms for low level vision from data?

Learning complicated object models for recognition

The community has made progress in recognizing frontal views of human faces using simple machine learning techniques. However, attempts to use similar techniques to recognize more complicated object classes such as human bodies have largely failed. Can we use more advanced learning algorithms to train recognition algorithms from labeled data?

2.7 Time table

Arrival at Dagstuhl will be on Monday 7.10.2002 in the evening.

Tuesday, 8.10.2002

Metric embeddings and similarity measures
Image partitioning
Neural Approaches

Wednesday, 9.10.2002

Learning approaches
Multiple views
New geometric and algebraic concepts
Evening discussion: Learning and Vision

3 Cooperating Institutions

Univ. Bonn (J. Buhmann)
Univ. Bielefeld (H. Ritter, G. Heidemann)
Albert-Ludwigs Univ. Freiburg (H. Burkhardt, N. Canterakis)
Univ. Mannheim (C. Schnörr)
Christian-Albrechts Univ. Kiel (G. Sommer, J. Pauli)
Hebrew University, Jerusalem (S. Peleg, N. Tishby, D. Weinshall)
Tel-Aviv-University (N. Sochen, who is also a member of the Technion's Ollendorf Center)
Technion Israel Institute of Technology, Haifa (Y. Zeevi, R. Meir)

4 Participating Young Scientists

(preliminary list): Alex Bronstein (Technion), Petr Doubek (ETH Zurich), Guy Gilboa (Technion), Pavel Kisilev (Technion), George Leifman (Technion), Katja Nummiaro (Leuven), Chen Sagiv (Technion).

5 Location and Time

We intend to have the workshop at Schloss Dagstuhl/Wadern, Oct. 7-10, 2002. Schloss Dagstuhl is a well-known, ideal location for computer science workshops and provides all the necessary facilities (modern lecture rooms, on-site accommodation and meal service, access to computer facilities and internet as well as a very well equipped computer science library).

Electronics
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OLLENDORFF MINERVA CENTER
FOR VISION AND IMAGE SCIENCES

Ollendorff Minerva Center for Vision and Image Sciences

German-Israeli Binational Workshop, October 20-21, 2004

Department of Electrical Engineering, Auditorium (10th floor)
Andre Meyer Building, Technion—Israel Institute of Technology, Haifa, Israel

09:00 – 09:30	**Reception and Registration**
09:30 – 09:40	**Welcome** **Prof. Aviv Rosen**, Senior VP Technion, Israel
09:40 – 09:50	**Introduction** **Prof. Yehoshua Zeevi,** Department of Electrical Engineering, Technion, Israel
Source Separation **Wednesday, October 20, Morning Session** **Chair: Prof. Arie Feuer, Department of Electrical Engineering, Technion**	
09:50 – 10:20	**Blind Source Separation, Deconvolution and Localization Using Sparsity Priors** **Dr. Michael Zibulevsky,** Department of Electrical Engineering, Technion, Israel
10:20 – 10:40	**A Fast Algorithm for Simultaneous Diagonalization of Matrices in Application to Blind Source Separation** **Andreas Ziehe**, Fraunhofer Institute FIRST, Berlin
10:40 – 11:10	**Off-Origin Hessians of the Characteristic Function and Their Use for Static or Convolutive Blind Source Separation** **Dr. Arie Yeredor,** Electrical Engineering Department, Tel-Aviv University, Israel
11:10 – 11:30	**Coffee Break**
11:30 – 11:50	**Blind Separation of Spatio-Temporal Data Sources** **Hilit Unger,** Department of Electrical Engineering, Technion, Israel
11:50 – 12:20	**Underwater Vision** **Dr. Yoav Schechner,** Department of Electrical Engineering Technion, Israel
12:20 – 12:40	**Blind Deconvolution Using the Relative Newton Algorithm and Learnable Sparse Representations** **Alex Bronstein,** Department of Electrical Engineering, Technion, Israel
12:40 – 13:00	**Efficient Non-parametric Independent Component Analysis** **Sarit Shwartz ,** Department of Electrical Engineering, Technion, Israel
13:00 – 15:00	**Lunch Break**

Variational Methods **Wednesday, October 20, Afternoon Session** **Chair: Dr. Danny Keren, Department of Computer Science, Haifa University**	
15:00 – 15:30	**Variational Deconvolution of Images Blurred with Known Kernels** **Dr. Martin Welk,** Saarland University, Saarbruecken, Germany
15:30 – 15:50	**Integrated Active Contours for Texture Segmentation** **Chen Sagiv,** Tel-Aviv University, Israel
15:50 – 16:20	**Image Enhancement by Generalized Diffusion** **Prof. Yehoshua Zeevi**, Electrical Engineering Department, Technion, Israel
16:20 – 16:40	**Coffee Break**
16:40 – 17:00	**Real-Time Variational Optic Flow Computation with Multigrid Methods** **Andres Bruhn**, Saarland University, Saarbruecken, Germany
17:00 – 17:30	**Relations between Diffusion Filtering and Wavelet Shrinkage** **Prof. Joachim Weickert,** Saarland University, Saarbruecken, Germany
3D & Medical Imaging **Thursday, October 21, Morning Session** **Chair: Part 1: Prof. Dan Adam, Department of Biomedical Engineering, Technion** **Chair: Part 2: Dr. Haim Azhari, Department of Biomedical Engineering, Technion**	
09:00 – 09:30	**Reception**
09:30 – 10:00	**Quantification of Spatial Structure of Human Bone Biopsies Using 3D Measures of Complexity** **Prof. Juergen Kurths**, University of Potsdam, Physics, Potsdam, Germany
10:00 – 10:30	**Modeling by Example** **Dr. Ayellet Tal,** Department of Electrical Engineering, Technion
10:30 - 11:00	**Volume Models for Anatomy Teaching and Surgery Simulation** **Prof. Hoehne** University Hospital Hamburg-Eppendorf, Hamburg, Germany
11:00 – 11:20	**Coffee Break**
11:20 – 11:50	**Experimental Evaluation of Image Quality in Medical Volume Visualization** **Dr. Andreas Pommert**, Institute of Medical Informatics, University Hospital, Hamburg-Eppendorf, Hamburg, Germany
11:50 – 12:10	**Segmentation of Thin Structures in 3D Medical Images** **Michal Holtzman Gazit ,** Department of Electrical Engineering, Technion, Israel
12:10 - 12:40	**On Image Processing and Computer Vision in Medical Imaging"** **Dr. Moshe Porat**, Department of Electrical Engineering, Technion, Israel
12:40 – 13:00	**Medical imaging - from Analog Information to Digital Data** **Hagai Kirshner**, Department of Electrical Engineering, Technion, Israel
13:00 – 14:30	**Lunch Break**

IRWIN AND JOAN JACOBS
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Image Acquisition & Enhancement

Open to Industry

Thursday, October 21, Afternoon Session

Chair: Part 1: Prof. David Malah, Department of Electrical Engineering, Technion

Chair: Part 2: Dr. Yonina Eldar, Department of Electrical Engineering, Technion

14:30 – 15:00	**Reception and Registration**
15:00 – 15:10	**Welcome** **Prof. Israel Cidon, Head of CCIT,** Department of Electrical Engineering, Technion
15:10 – 15:40	**Implicit Beltrami Flow in Higher Co-Dimensions** **Dr. Nir Sochen**, Department of Applied Mathematics, Tel-Aviv University, Israel
15:40 – 16:10	**A Feature Selection Algorithm Based on the Global Minimization of a Generalization Error Bound** **Prof. Ron Meir,** Department of Electrical Engineering, Technion, Israel
16:10 – 16:30	**Color Image Denoising and Blind Deconvolution Using the Beltrami Operator** **Ran Kaftory,** Department of Electrical Engineering, Technion, Israel
16:30 – 16:50	**Optimal Sparse Representations in Blind Deconvolution and Blind Source Separation: a Learning Approach** **Michael Bronstein,** Department of Electrical Engineering, Technion, Israel
16:50 – 17:10	**Enhancement of Color Images by Efficient Demosaicing** **Liron Grossman,** Department of Electrical Engineering, Technion, Israel
17:10 – 17:30	**Coffee Break**
17:30 – 18:00	**Structural Adaptive Smoothing Methods for Imaging Problems** **Dr. Polzehl,** Weierstrass-Institut für Angewandte Analysis und Stochastik (WIAS), Germany
18:00 – 18:30	**Hybrid Imaging: Recent Advances in Physics-based Vision** **Dr. Yoav Schechner,** Department of Electrical Engineering, Technion, Israel
18:30 – 18:50	**Inlier-based Independent Component Analysis** **Frank Meinecke,** Fraunhofer Institute FIRST, Berlin, Germany
18:50 – 19:00	**Concluding Remarks**

Organizing Committee:

Prof. Klaus-Robert Mueller, Fraunhofer Institute FIRST, Berlin, Germany
Prof. Joachim Weickert, Saarland University, Saarbruecken, Germany
Prof. Yehoshua Zeevi, Electrical Engineering Department, Technion, Israel

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